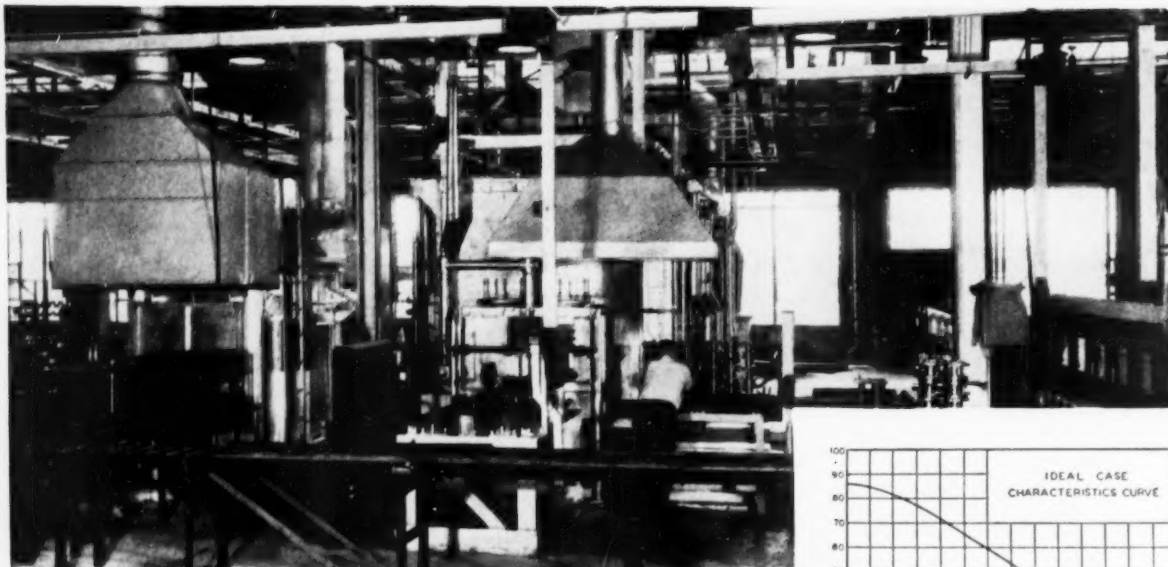
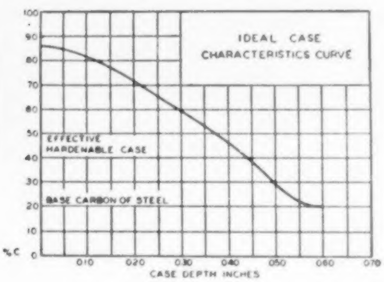
METAL PROGRESS

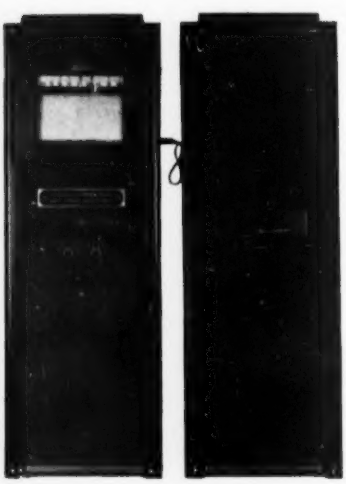
OCTOBER 1954





on the nose every time

WITH SURFACE AUTOCARB AUTOMATIC CARBON POTENTIAL CONTROL



New high physicals in carburized gears—better tooth-to-tooth and gear-to-gear uniformity—faster cycles—automatic compensation for changes in work surface area during furnace operation . . .

These are the chief benefits Warner Gear Division, Muncie, Ind., achieves in its most recent continuous gas carburizing line, using the 'Surface' fully automatic carbon potential control system. In a nutshell: The Surface dewpoint recorder-controller periodically checks carbon potential in each of three zones in the furnace (in a range of .3 to 1.1% carbon), controls mixing valves to deliver correct additions of air or gas to maintain desired carbon potential in each zone. This system eliminates the human element in controlling carbon potential. It also provides Warner Gear with the necessary close control required for the practical carburizing of gears with near-eutectoid surface carbon concentrations.

Write for Literature H-54-2, or better still, see the demonstration of the 'Surface' automatic direct-reading carbon potential control system—at the Metal Show in Chicago Nov. 1-5: Booth 714.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress

October, 1954 **Vol. 66, No. 4**

Cover by Jose Vasquez

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Table of Contents Continued . . .

As I was saying...

H**ERE'S THE** big issue — the convention and show number of *Metal Progress* — and I'm dropping everything to get this message inside the deadline hour. All of which makes me very happy that I'm not writing a daily column. I like to write this column because I just pick out some good member (one of the six I know who reads this epistle) and write him a letter. So here goes:

Dear Harry: Ye Gods! it seems like ages since I've seen you and heard from you (not since that last complaint about the damaged book we sent you) but I guess it's my fault. You have been busy and all I have had to do was prepare for the two Metal Shows and Congresses in Chicago and Los Angeles, and get material together for a two-day meeting of the Board of Trustees.

You'll be interested in a memo I presented to the Board dealing with the plans and objectives for the future of the A.S.M. for some ten years to come. I'll tell you all about it when I see you in Chicago, Nov. 1 thru 5, at the Convention. I was delighted to receive a note from Past-President Ben Shepherd giving a comment on my proposed future A.S.M. activities, which was a quotation by Daniel H. Burnham:

> "Make no little plans; they have no magic to stir one's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency. Remember that our sons and grandsons are going to do things that would stagger us."

And there was nothing "little" contained in my plans for A.S.M.'s progress. Another P. P. encouraged me with the statement that "Vision is Indispensable to Progress", and I can add a paraphrase of my own from an unknown quotation "The Society that does not progress will perish". The alternative to progress is to pass the hat every time one has a thought about increased service to the members. More about A.S.M.'s future in the future.

I just had a report from the Chicago hotels that over 6000 room reservations have been granted for Show Week, and I hope you have your acknowledged reservation.

I've good news for you re the annual banquet. While in the past it has been a very dignified affair, it usually closed soon after 10:00 p.m. and left all the banqueters with no place to go. So it was decided to have a first-rate orchestra for dancing in the Red Lacquer Room of the Palmer House, and in addition (although I know you are still on the wagon) have available refreshments of pop, coke, 11-Up, O.J., etc., with table and stand-up (foot on rail) service both before the banquet and at the dance.

A new feature of Convention Week will be the Distinguished Service Luncheon held on Friday at the Saddle & Sirloin Club at the Stock Yards for all 25-year members in attendance at Chicago and for junior members from the educational institutions within a 150-mile radius of the convention city. It will be a mingling of the experienced and the novice.

I mentioned about the A.S.M. Board of Trustees being in Cleveland for a two-day meeting—and meeting at the same time were the Metals Handbook Committee, the trustees of the ⊕ Foundation for Education and Research, the ⊕ Teaching-Award-for-Metallurgy Committee, and in addition, we invited all of the past presidents and their families to the pow-wow.

That made a full house, so Mill and I decided to have a picnic at Sunnimoor in the afternoon and evening of Thursday. The morning was overcast and we were quite fearful of having a wet party but I realize now that we had nothing to fear from the weather. We gave all our guests Indian headbands with an eagle feather and these insignia produced a great cordial "Heap How" among all the 115 squaws and chiefs. Near the close of the dancing a friendly guy gave me a headband with three feathers maintaining that the "Spirits" were low and that I should represent "Three Feathers" to replenish the inventory at a low cost. Mill and I had such a good time we think we will have another picnic next year for more good A.S.M. Indians.

I gotta go! Just about out of white space and they tell me that they cannot condense type, at least not the type of column I write.

But I'll see you in Chicago, Nov. 1 through 5, and bring Betty along with you. She'll enjoy meeting your friends.

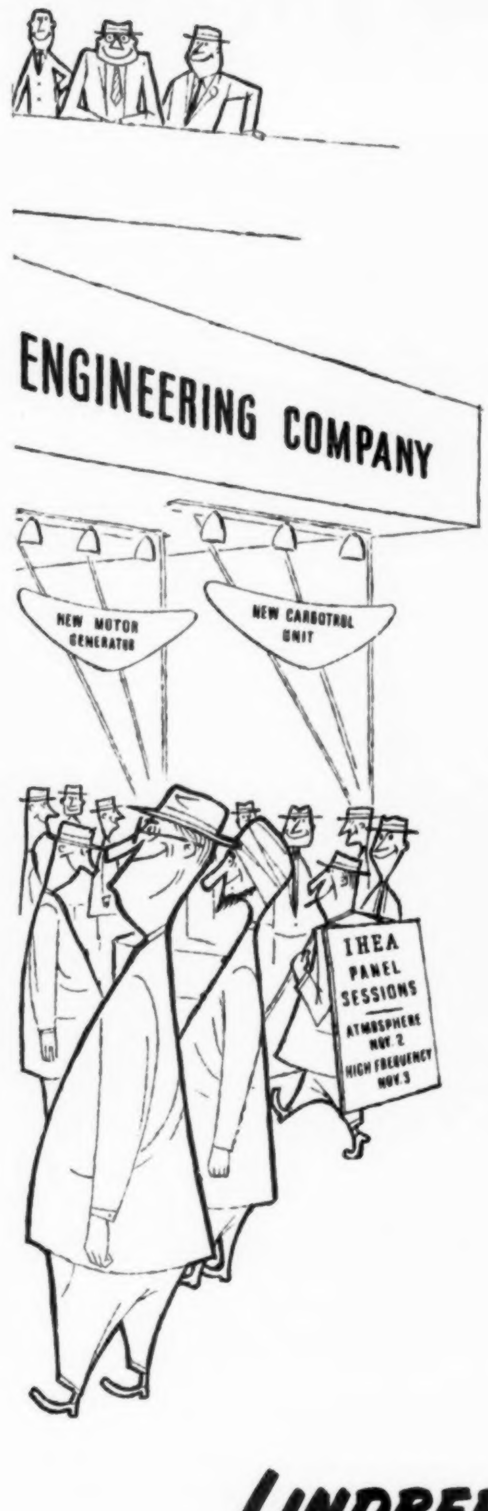
With my love to Betty and kindest regards to you, I am

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS


BOOTH
662
LINDBERG
NEW ATMOSPHERE GENERATOR
CARBON and SULFUR DETERMINATOR
CARBONITRIDING FURNACE
HEAT FOR INDUSTRY
We know our Booth No. 662 at the Metal Show will be this busy, but we'll have plenty of our people there to show you the new answers Lindberg engineers have for your industrial heating problems. The signs in the sketch indicate the types of equipment we will be showing, all products of Lindberg's engineering know-how. Be sure to drop in.



Don't miss Lindberg's special tour

Plan to devote a couple of hours to the special tour Lindberg has arranged for you. This will take you to Lindberg's beautiful Chicago plant, where you will see how our famous "Heat for Industry" equipment is engineered and built.

Then we will take you to the model new plant of Lindberg Steel Treating Company in Melrose Park, where you will see much of this equipment in actual operation.

Just ask any of our Lindberg people in Booth No. 662, and the trip can be arranged at your convenience —or telephone us at MOnroe 6-3443.

Lindberg Industrial Corporation (Field-erected equipment) representatives will also be in Booth 662.

Lindberg Engineering Company, Chicago, Illinois

Lindberg Steel Treating Company, Melrose Park, Illinois

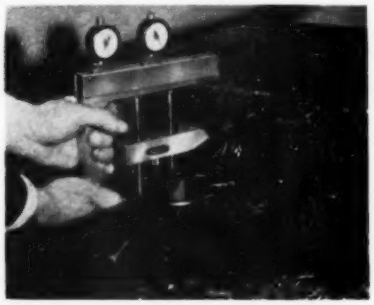
LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois
Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California
Associate Companies: Lindberg Industrial Corporation, Chicago, Illinois
EFCO-Lindberg, Ltd., Montreal, Canada • Lindberg Italiana, Milan, Italy

engineering digest OF NEW PRODUCTS

Portable Hardness Testers

Portable hardness testers available in two sizes have been announced by Riehle Testing Machines Div. Model PHT-1 tests specimens up to 4½ in.



in diameter, while Model PHT-2 accommodates specimens up to 12 in. Testers weigh only a few pounds, come in handy carrying cases, and simply clamp onto specimens. They employ standard Rockwell indentor and loadings.

For further information circle No. 1255 on literature request card on p. 32-B.

Aluminum Alloy

A new high-strength, non-heat-treatable aluminum alloy, K186, especially designed for weldability and adaptability to structural applications has been announced by Kaiser Aluminum & Chemical Corp. The new alloy is available in sheet and plate form, in a full range of tempers. Nominal composition is 4.0% magnesium, 0.45% manganese and 0.10% chromium. Typical mechanical properties of K186 in various tempers are:

Temper	T S 1000 psi	YS 1000 psi	Elong., % in 2 in.
0	38	17	22
H 32	42	30	12
H 34	47	37	10
H 112	39	19	14

In the annealed condition, K186 has a tensile strength approximately 30% greater than 52S. Standard finishing procedures may be used with K186 and corrosion resistant anodized finishes can be applied. Typical applications include unfired pressure vessels, structural towers, welded boat hulls, rocket motor tubing, guided missile containers, aircraft carrier elevators, trusses and girders, truck and trailer frames, tanks, pipelines and scaffolding.

For further information circle No. 1256 on literature request card on p. 32-B.

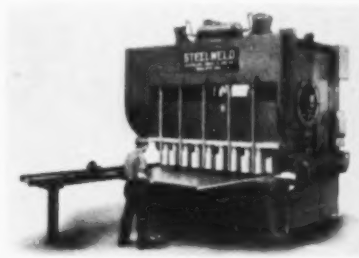
Controllers

Leeds & Northrup has announced a new Speedomax Type H indicating controller and a new line of automatic temperature controls. Chief advantages of the new temperature controls are the better than 50% reduction in panel space, continuous indication of valve position and stepped-up rate action and reset response. The new line will be available for the usual control actions — proportional action; position-adjusting type, and duration adjusting type, the latter two having proportional, reset and rate actions.

For further information circle No. 1257 on literature request card on p. 32-B.

Heaviest Plate Shear

A shear which will cut heavier plate than any previously built has been announced by the Cleveland Crane & Engineering Co. The machine is designed for production shearing of steel plate in sizes up to 8 ft. long by 1½ in. thick. It is ruggedly constructed with end housings, crown and bed welded into a solid one-piece unit. The machine operates on the pivoted-blade principle, the blade traveling in a circular path without the use of guides and slides common with guillotine-type shears. The operating speed is



twenty-two strokes per minute. Adjustments are provided to enable slitting and notching.

For further information circle No. 1258 on literature request card on p. 32-B.

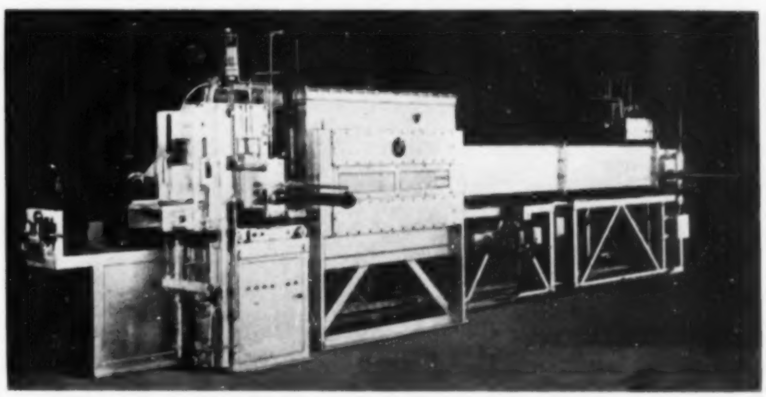
Copper Alloy

A new copper-manganese-tin alloy will be shown by the Malayan Tin Bureau at the National Metal Exposition. This new copper alloy, containing 15% manganese and 6% tin, is a recent development of the Tin Research Institute laboratory in England. The white, ternary alloy has

Automatic Furnace

An automatic pusher type furnace specially designed for bright brazing stainless steel at temperatures up to 2150° F. has been announced by the Harper Electric Furnace Corp. It is adaptable for continuous brazing stainless steel with copper or stainless steel brazing compound. Sequence of operations is automatically timed and synchronized. The furnace is a self-contained unit and is engineered for integration in production lines.

For further information circle No. 1259 on literature request card on p. 32-B.



good mechanical properties, can be readily cast, forged, rolled, stamped and otherwise processed. It is corrosion resistant and can be plated. Since manganese is fairly plentiful, this alloy is cheaper than nickel silver.
For further information circle No. 1260 on literature request card on p. 32-B.

Quenching

Controlled quenching of round, flat, shafted, or irregular parts is provided by a series of quenching presses made by the Gleason Works. These machines are designed to hold and align heated parts during the quenching process, so that they may be hardened with a

minimum of distortion. Operation of the quenching cycle is completely automatic. Quenchant is forced uniformly over and around the heated part, the rate of flow being controlled at all stages of the quenching cycle. Each quenching press has a built-in pumping system and reservoir. In presses for flat, round and irregular parts, the heated part is held between two dies while the quenching takes place. The rolling quench machine for quenching shafts or similar parts rolls the part under pressure during the quenching cycle so that hardening is achieved with minimum distortion.
For further information circle No. 1261 on literature request card on p. 32-B.

Carbides for Machining

Adamas Carbide Corp. has announced four carbide grades for applications where extremely difficult machining operations are involved. Grade 434 contains four carbides which give it high shock resistance, as well as good wear resistance for very heavy cuts, both continuous and interrupted. This grade cannot be used for finish cutting. Grade 548 finds application for general finishing and light roughing and finishing when interrupted cuts are encountered. Grade GG is a high tantalum grade, suitable for hot working and removal of hot welding flash. It can also be used for extremely heavy roughing cuts on steel. Grade 474 is a modification of grade GG described above. It is not as strong, but will give better wear resistance.
For further information circle No. 1262 on literature request card on p. 32-B.

Electronic Controller

Wheelco Instruments Division has announced a new instrument for controlling process variables in such operations as heat treating and extrusion. The housing of the instrument is in two compartments, one for the meter, the other for the controls. Meter movement is of the plug-in type and self contained. A modification of the basic high-resistance D'Arsonval galvanometer movement was made. Standard components are used in the electronic control chassis so that they can be easily replaced. A conical viewing window makes for easy scale reading.

For further information circle No. 1263 on literature request card on p. 32-B.

Welding

A new organic welding material has been announced by U. S. Stoneware Co. Metal to glass, metal to porcelain, and metal to metal adhesions pass rugged peel and shear tests. Tygoweld comes in rod form and can be applied with moderate heat and little or no pressure. Powder and paste adaptions are also available.

For further information circle No. 1264 on literature request card on p. 32-B.

Hard-Facing Alloys

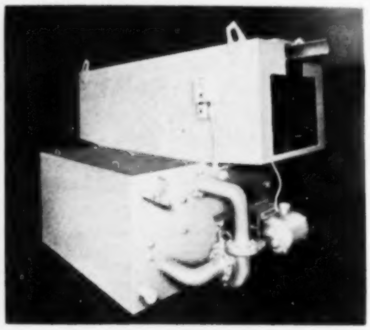
Three new cobalt-chromium-tungsten hard-facing alloys in welding rod form have been announced by Crobalt, Inc. They are applied to steel and cast iron parts to increase high hardness and high resistance to abrasion, corrosion, oxidation and impact. They retain these properties at red heat, can be heated to 1600° F. with no permanent loss of hardness, and are not affected by repeated heating and cooling. These alloys are applied by oxy-acetylene torch or inert arc welding using standard hard-facing proce-

dures. They consist of a dense, hard layer of complex wear-resistant carbides evenly distributed in a cobalt matrix.

For further information circle No. 1265 on literature request card on p. 32-B.

Spray Washer

A new spray washer that can be used as a single unit or combined into a multi-stage washer to suit the needs of the user has been announced by the Detrex Corp. Units can be assembled either by bolting or welding. A range of sizes from a spray length of 4 through 10 ft. is available. Each

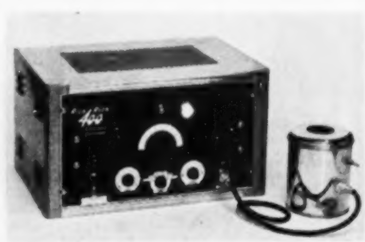


washer unit will accommodate work up to 30 in. wide. Several different heights are available in the washer openings—from 24 to 60 in. The tanks themselves are constructed of 3/16 in. steel plate and hold 600 to 1000 gal. of solution. The washer is designed for use of phosphate coatings of the iron-phosphate type.

For further information circle No. 1266 on literature request card on p. 32-B.

Ultrasonic Energy Generator

Rich-Roth Laboratories have announced a wide-range, 400-watt, ultrasonic energy generator, and a variety of transducers for production line or laboratory degreasing, emulsifying



and impregnating. The 400-watt generator is tunable over the frequency range from 10 to 1200 kc. per sec. Ready selection of output impedances couples the generator to many types of piezoelectric and magnetostrictive transducers. New types of transducers include metal jacketed and lined fully enclosed water cooled treatment chambers where process materials are in contact only with metal surfaces.

For further information circle No. 1267 on literature request card on p. 32-B.

Miniature Thermal Switch

MiniTec has announced a chemical-type thermal switch 3/16 in. in diameter and 3/16 in. long. Below a predetermined switching temperature the resistance of the MiniTherm exceeds 10 megohms. When the switch reaches its switching temperature, the resistance becomes permanently less than 0.10 ohm. Current rating is 5 amp., a-c. or d-c., continuous duty. MiniTherms are available at switching temperatures from 150 to 400° F. in increments of 25°, and from 400 to 1000° F. in increments of 50°. Accuracy is plus or minus 2%. MiniTherm can follow temperatures rising at the rate of 100° per second.

For further information circle No. 1268 on literature request card on p. 32-B.

Metering Loader

The Industrial Heating Equipment has announced a new metering loader which will handle 100 to 5000 lb. per

hour of miscellaneous small parts such as bolts, nuts, rivets, through the use of a variable speed drive having a 20 to 1 variation. The loader can be made to distribute the work evenly across the full width of the conveying mechanism in the appliance being fed. The standard hopper holds up to 1000 lb. of average size bolts.

For further information circle No. 1269 on literature request card on p. 32-B.

Carbon Controller

The new Autocarb automatic continuous carbon controller has been announced by Surface Combustion Corp. This instrument, used in conjunction with the dew point recorder, provides

New facts for your file on

USS CARILLOY STEELS

USS Carilloy steels minimize distortion in power steering units for cars

POWER steering units are precision machines. Every part must fit exactly. Parts must be interchangeable. They must be made to finished tolerances as small as .0001". They must be heat treated with minimum distortion.

These rigid requirements dictate the use of accurately controlled *alloy* steels that can be *quenched in oil*. These steels must respond uniformly to heat treatment, time after time, so that many thousands of parts can be made —*all exactly alike*. USS CARILLOY steels are used extensively in power steering units because they help to insure the uniformity that is essential in all critical parts.

CARILLOY steels are giving excellent service daily in a wide variety of precision parts for automobiles, aircraft, trucks, farm equipment, construction machinery, rotating machines, and many other applications. These high quality steels are meeting some of the toughest requirements known to industry. They can meet yours. For information write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Torque Testing of completed steering unit. Even the heaviest steering loads require only 3 lbs. pull by the driver of an automobile with power steering. In addition, road shocks are cushioned by the power steering unit.

Worm Shafts are ground to within .0005". Alloy steel must be used for these parts so they can be quenched in oil with a minimum of distortion to maintain the close tolerances.

Heat Treatment. USS CARILLOY steels have the uniformity in response to heat treatment that is so necessary to obtain the high strength, adequate ductility and minimum of distortion required in power steering units.

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

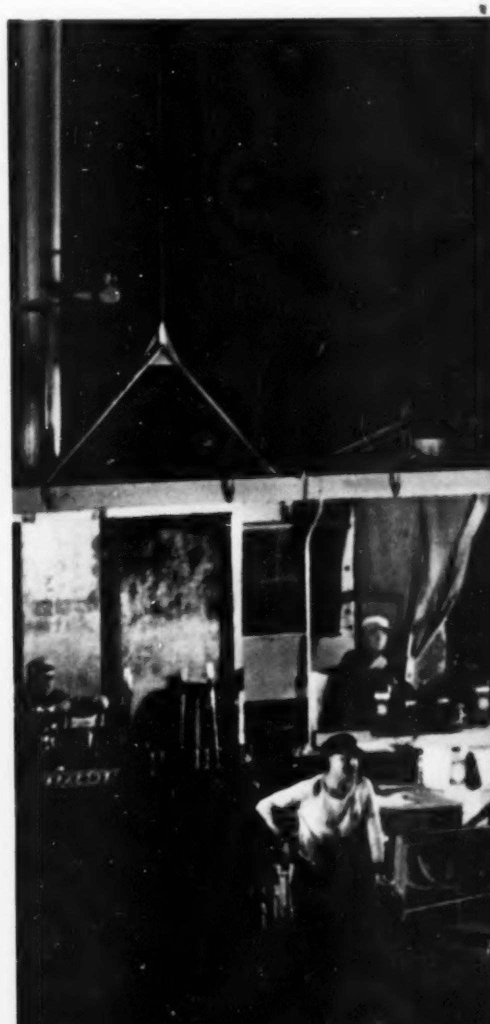
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST TO COAST

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

"We really had to put

says Frank Andras,



THAT piece of red-hot steel in the press jaws will soon be doing one of the toughest jobs known. It will crush taconite, just about the hardest of ores. This rugged service requires the combination of a special nickel-bearing alloy steel, and high reduction to secure a sound forging. In the words of Frank Andras (a U. S. Steel Pressman for 17 years), "We had to squeeze her down until the cross-sectional area was ⅓ of the original ingot."

This forging will serve as the shaft in a gyratory crusher. It will be used in a taconite reduction plant in northern Minnesota where temperatures drop to 30° and 40° below zero, a bitter cold that causes brittle failure in ordinary steels. The shaft operates like the pestle in a druggist's mortar and pestle. It wobbles and rolls, splitting the stubborn, rock-like taconite into smaller pieces.

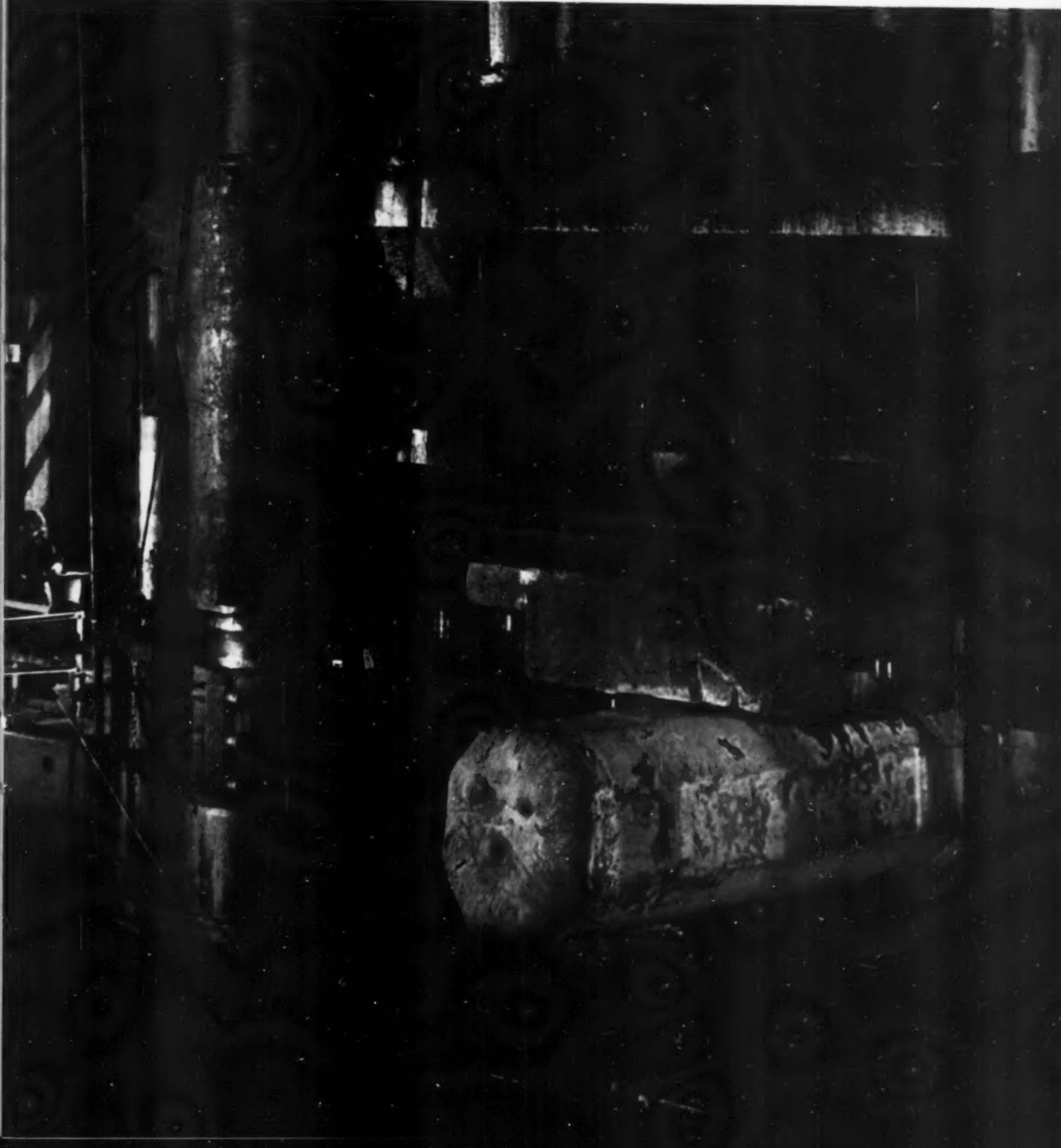
It requires the finest steel and equipment to produce USS Quality Forgings that can withstand this kind of brutal service. Equally important are the men who actually work on each forging. Frank Andras, for example, has been a U. S. Steel employee for 33 years. His father was a forging machinist in the same shop for 50 years. His brother has been a Heater for 16 years. These are typical of the men who work on your USS Quality Forgings.

Write for our free 32-page booklet that describes USS Quality Forgings. United States Steel, Room 4463, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS Quality

the squeeze on this forging"

U. S. STEEL PRESSMAN

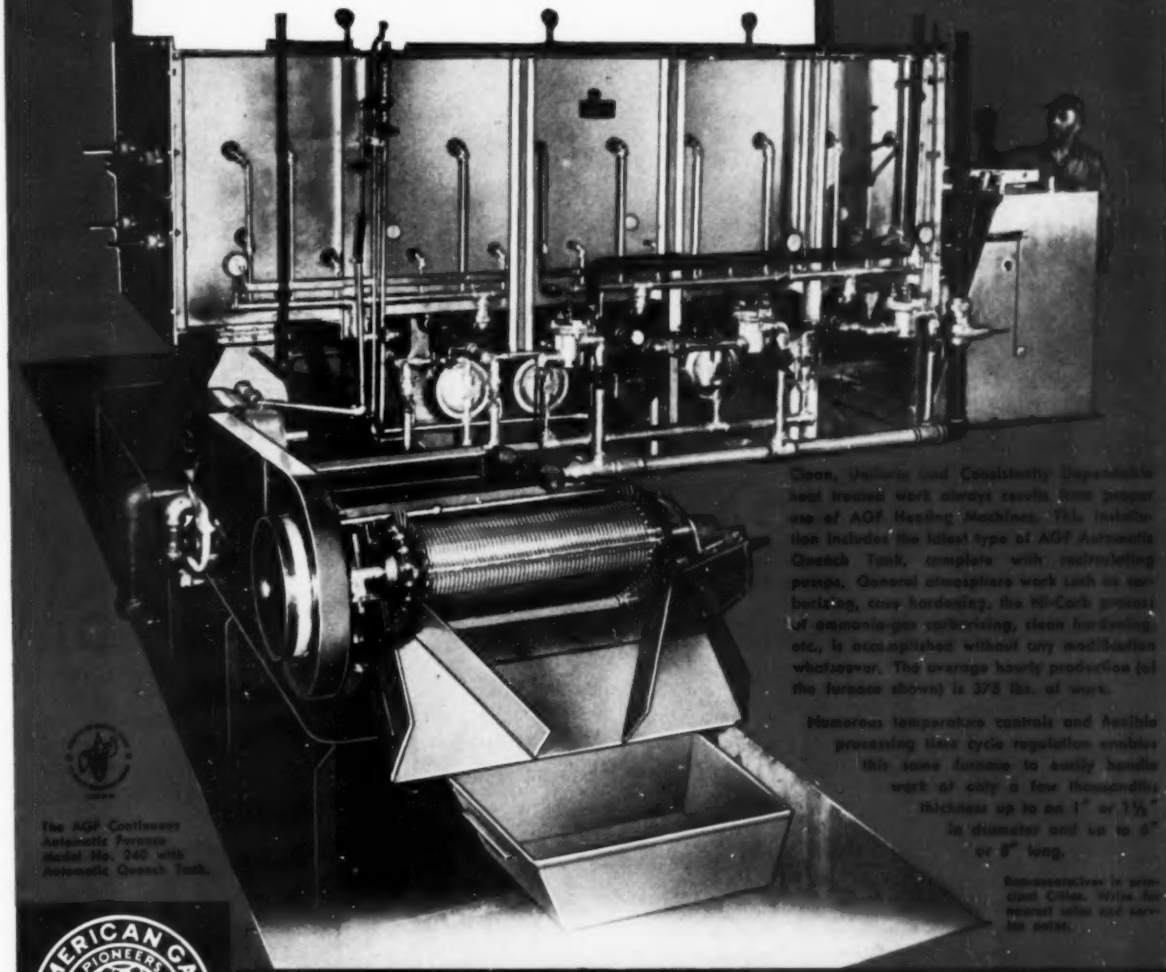


Heinzelman Installs Another . . .

AGF HEAT TREATING FURNACE

"AGF Customer of Long Standing"

Fred Heinzelman & Sons—New York—Since 1915—one of America's oldest and most dependable commercial heat treaters—after using a smaller AGF machine of the same type, liked its adaptability so much that they bought the newest AGF Reciprocating Furnace with the stationary muffle and moving hearth.



Clean, Uniform and Consistently Dependable heat treated work always results from proper use of AGF Heating Machines. This installation includes the latest type of AGF Automatic Quench Tank, complete with recirculating pumps. General atmosphere work such as carburizing, case hardening, the Ni-Carb process of ammonia-gas carburizing, clean hardening, etc., is accomplished without any modification whatsoever. The average hourly production (of the furnace shown) is 375 lbs. of work.

Numerous temperature controls and flexible processing time cycle regulation enables this same furnace to easily handle work of only a few thousandths thickness up to an 1" or 1½" in diameter and up to 6" or 8" long.

Representatives in principal Cities. Write for nearest sales and service point.

The AGF Continuous Automatic Furnace Model No. 240 with Automatic Quench Tank.

AMERICAN GAS FURNACE CO. PIONEERS 1878

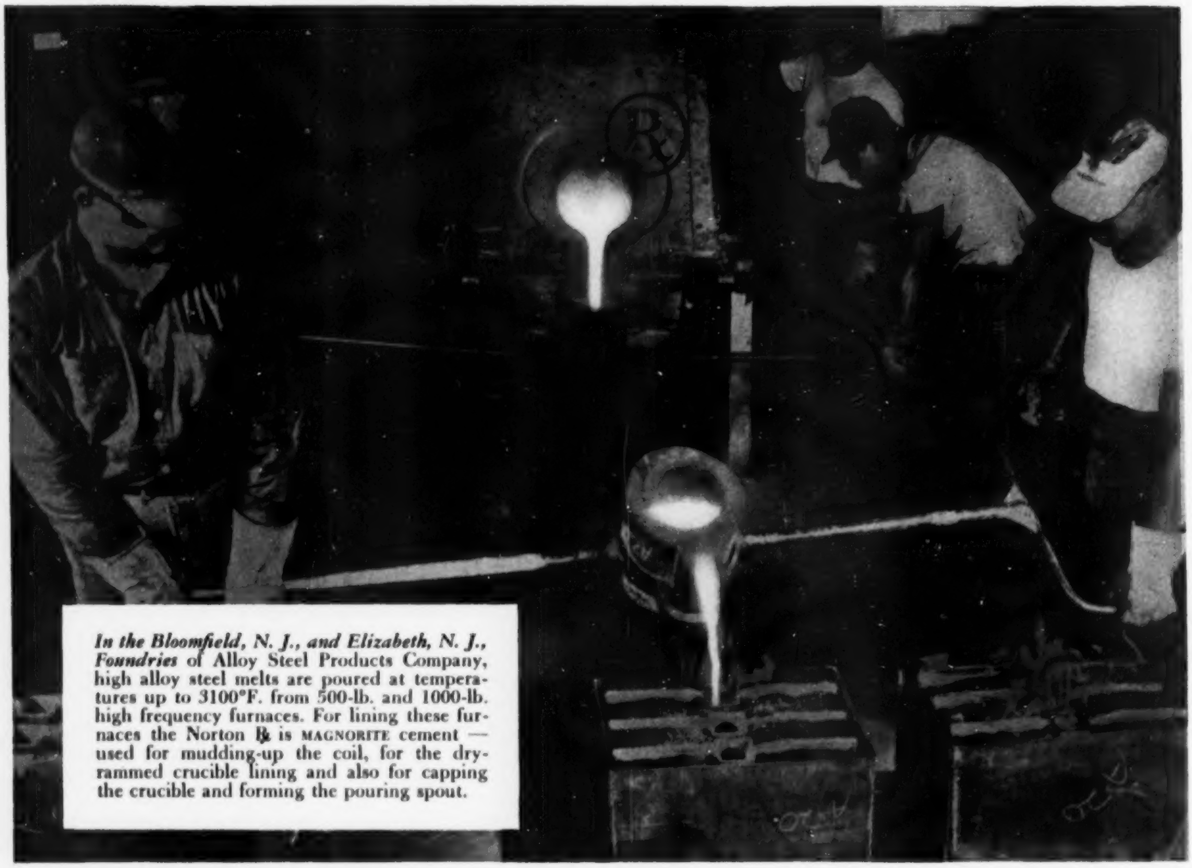
AMERICAN GAS FURNACE CO.

1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

Visit AGF at the Metal Show Booth No. 843H

Another Norton ℞ *on the job!*

*Makers of famous Aloyco Valves, after testing many cements, standardize on MAGNORITE**



In the Bloomfield, N. J., and Elizabeth, N. J., Foundries of Alloy Steel Products Company, high alloy steel melts are poured at temperatures up to 3100°F. from 500-lb. and 1000-lb. high frequency furnaces. For lining these furnaces the Norton ℞ is MAGNORITE cement — used for mudding-up the coil, for the dry-rammed crucible lining and also for capping the crucible and forming the pouring spout.

Over the years the Alloy Steel Products Company, world's largest specialists in high alloy, corrosion resisting valves, have tested many refractory materials for the linings of their high frequency induction furnaces.

These tests proved that Norton MAGNORITE cement, engineered-to-the-job, lasted longer and performed better than any other material. As a result, Aloyco now uses MAGNORITE cement exclusively for lining these furnaces — still another example of how Norton refractories and refractory materials are *engineered and prescribed* to provide time-and-money-saving ℞'s.

The Right ℞ For YOU

For your own induction furnace operations, Norton will be glad to engineer MAGNORITE cement to your exact requirements. It withstands temperatures up to 3250°F. Its high-rammed density offers great resistance to metal penetration, erosion and chemical attack. And it is designed to expand slightly when sintered so that the crucible lining is free from shrinkage cracks that often lead to furnace failures. Why not run a test on one of your furnaces soon?

This engineering service applies, of course, to any metal-melting problem you may have. Working with MAGNORITE*, ALUNDUM*, CRYSTOLON* and fused stabilized zirconia cements and special shapes, Norton engineers are sure to come up with the right answers. For details, see your Norton Refractories Engineer, or write to NORTON COMPANY, Refractories Division, 329 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

NORTON
REFRACTORIES
Engineered... ℞... Prescribed

Making better products ... to make other products better

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

for continuous control of the carbon potential of the furnace atmospheres. It is used for control of furnace atmosphere in gas carburizing, clean hardening and other heat treating processes.

For further information circle No. 1270 on literature request card on p. 32-B.

Vacuum Furnace

A 1000 lb. capacity vacuum furnace, the largest constructed for melting and centrifugally casting high-temperature alloys, has been designed and built by F. J. Stokes Machine Co. at Utica Drop Forge & Tool Corp. It will

be used to make high-purity alloys for turbine blades and discs for jet engines. Vacuum processing will give these alloys greater tensile and stress-rupture strength than conventional atmospheric-processed material. Utica's new furnace is designed to carry out all the heating, melting, alloying, and casting operations within the vacuum chamber.

For further information circle No. 1271 on literature request card on p. 32-B.

Inspection

A new magnetic particle inspection kit has been announced by Magnaflux Corp. It is designed for preventive maintenance inspection, weld inspection, and limited volume inspection of any magnetic part where surface cracks are suspected. The Magnaflux

Y-5 yoke kit comes in a metal carrying case, about the size of a fishing box, and weighs less than 30 lb. The yoke itself is the magnetizing and testing instrument. Powder, powder bulbs, and operating instructions complete the kit. It is equipped with a 100 ft. cord and draws only 6 amp. from any 110 volt a-c. line.

For further information circle No. 1272 on literature request card on p. 32-B.

Zinc Paint

A new paint which contains 93 to 95% metallic zinc has been developed by Sealube Co. It can be applied directly over rusted surfaces, and it will check further rust spread and even reduce the amount of rusting present at the time of application. The protection provided by this new paint is based on electrochemical action. Corrosion attacks the anode, or zinc layer, leaving the steel untouched. Zrc can be applied over adherent rust, mill scale or old paint. The surfaces to be protected should first be wire-brushed to remove loose scale and flakes. Brushing on is the preferred method of application, although it may be sprayed on.

For further information circle No. 1273 on literature request card on p. 32-B.

Small Chilling Unit

A new low temperature chilling machine, designed to meet the needs of small heat treating departments and laboratories, has been announced by Cincinnati Sub-Zero Products Co. Weighing just 500 lb., it is 20 by 18 by 43 in. The capacity of the chilling chamber is 1 cu.ft. Temperature range

with air circulator is from +70 to −120°. Temperature range from +250 to −120° F. can be obtained with the addition of a heater. For testing requirements, a wide variety of control instrumentation is available.

For further information circle No. 1274 on literature request card on p. 32-B.

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WHAT'S NEW IN MANUFACTURERS' LITERATURE

1285. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Instrument*

1286. Alloy Castings
22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

1287. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U.S. Steel*

1288. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1289. Aluminum
12-page booklet on extruded shapes, tube and pipe, coiled sheet, forgings and properties of aluminum alloys. *Revere*

1290. Aluminum Coating
Article on hot dip coating of ferrous metals with aluminum and aluminum alloys from "Tips and Trends". *Ajax Electric*

1291. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1292. Aluminum Forgings
Booklet describes facilities for aluminum extrusion and forging. *Bridgeport Brass*

1293. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

1294. Ammonia for Heat Treat
Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". *Armour*

1295. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1296. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1297. Atmospheres
12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

1298. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

1299. Barrel Finishing
New brochure on tumbling barrel and the deburring and burnishing of stampings, castings and other metal parts. *Abbott Ball Co.*

1300. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

1301. Bending
Catalog on presses for bending, forming, blanking, drawing and multi-punching. *Cleveland Crane & Engineering*

1302. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1303. Beryllium
20-page booklet describes beryllium products, including the pure metal, oxide and alloys. *Beryllium Corp.*

1304. Beryllium Alloys
New 4-page bulletin on beryllium casting ingots and master alloys gives uses for these beryllium products and includes data on composition and properties. *Penn Precision Products*

1305. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses and gives engineering data. *W. M. Chace*

1306. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1307. Black Oxide Finish
Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1308. Blackening Compounds
Bulletin on blackening compounds for ferrous alloys to AMS Spec 2485. *Swift Industrial Chemical*

1309. Blast Cleaning
New 24-page catalog 1210 on equipment and accessories for blast cleaning and dust control. *Pangborn*

1310. Blowers
Bulletin 100-53 on combustion air blowers of 8 to 20 oz. pressures. *Western Products*

1311. Brass Wire
10-page booklet gives properties, finishes, chemistry of extruded cold heading brass and copper wire. *Chase*

1312. Brazing
Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

1313. Brazing
Bulletin 5889 on furnace and induction brazing installations and methods. *General Electric*

1314. Brazing
24-page Bulletin 20 on advantages of Easy-Flo silver brazing alloy, with information about joint design and fast production methods. *Handy & Harman*

1315. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

1316. Brinell Machine
Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

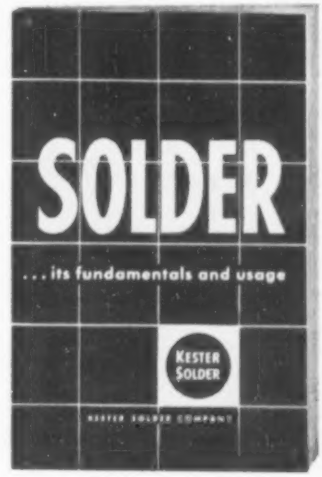
1317. Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

1318. Burners
Bulletin 123 on new series of burners for multi-purpose furnaces. *North American Mfg.*

1319. Cam
Bulletin on three dimensional cam which has 720 stations on just 1 sq. in. of surface. Engineering and production data. *Parker Stamp Works*

1320. Carbides
64-page catalog 52 gives latest information on carbide tooling. Details on all types of cutting tools. Tables for grade selection and cutting speeds. *Kennametal*

1284. Solder
This 80-page book on "Solder—its fundamentals and usage" was written to provide the solder user with a study of industrial applications and usage. Sections on the nature of sol-



der, the soldering flux, flux-core wire solder, external soldering fluxes, solid and special type solders and the application of solder make up the book. Charts, tables and photographs are included. *Kester Solder Co.*

1321. Carbides
84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

1322. Carbon Brick
Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

1323. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1324. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1325. Carburizing
16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

1326. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. *American Cyanamid*

1327. Castings, Bronze
16-page booklet on sand and centrifugal castings. *American Non-Gran Bronze*

1328. Casting Specifications
Design values for five grades of heat resistant castings. *Ohio Steel Foundry*

1329. Centrifugal Castings
Bulletin on centrifugal castings of meehanite, ni-resist and special iron alloys. *Shenango-Penn Mold*

1330. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

1331. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

1332. Cleaners
Data folder on silicated and nonsilicated cleaners, alkaline and solvent emulsifiers, strippers. *Cowles*

1333. Cleaning
Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

1334. Cleaning
8-page bulletin on cold solvent type metal cleaning machines and parts washers. *Graymills Corp.*

1335. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey Ferguson*

1336. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning," discusses tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

1337. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

1338. Cleaning Compound
Bulletin B-6 on water displacing compound for producing unspotted, dry surfaces. *Apothecaries Hall*

1339. Cold Treatment
Bulletin on sub-Arctic industrial cabinets for metal treating and research and production testing. *Tenney Eng.*

1340. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1341. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

1342. Continuous Annealing
Article on continuous production annealing of screws, bolts, rivets. *Sunbeam*

1343. Continuous Casting
24-page book, "Better by the Mile", de-

scribes how the Rossi continuous casting machine works. History of continuous casting. *Scovill Mfg.*

1344. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

1345. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

1346. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

1347. Controller
12-page catalog 53-10 on stack-type pneumatic controllers for process variables. *Fischer & Porter*

1348. Controllers
80-page catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

1349. Controllers
48-page bulletin P 1260 on pyrometers, thermometers, control valves for furnaces, ovens, dryers. *Bristol*

1350. Copper Nickel Alloys
8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

1351. Corrosion Resistance
32-page brochure on causes of corrosion and means of combatting them. Choice of materials for condenser tubes. *Revere*

1352. Creep Testing
Bulletin 4208 on five types of creep testing machines for standard sized metal specimens. *Baldwin-Lima-Hamilton*

1353. Creep Testing
Data on operation and instrumentation of Arcweld lever arm creep testing machine. *Minneapolis-Honeywell*

1354. Cutting Machines
Catalog of abrasive cutting machines including wet or dry, hand, semi-automatic or fully automatic and in a variety of sizes. *Campbell Machine Div.*

1355. Cutting Off
8-page bulletin on circular saw blades for cutting off. *Motch & Merryweather*

1356. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

1357. Cutting Oil
Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

1358. Deep Drawing
Reprint on new deep drawing technique involving single-stroke dies and eliminating intermediate operations. *Schnell Tool & Die*

1359. Degreasing
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

1360. Descaling
Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pangborn Corp.*

1361. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

1362. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1363. Design of Dies
32-page bulletin on design of dies for upset forging. Also rules for upsetting and examples of forgings. *Ajax Mfg.*

1364. Dew Point Control
Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

1365. Die Casting
Bulletin on automatic pouring unit for aluminum die castings. *Ajax Engineering*

1366. Die-Casting Machines
Case histories of companies using various types of die-casting machines. *Kux Machine*

1367. Die-Casting Machines
Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

1368. Die Castings
Folder on possibilities and advantages of die castings. *Precision Casting Co.*

1369. Die Sets
New catalog shows complete line of ball bearing die sets. *Lempco Products*

1370. Die Steel
Data on air hardening, free machining die steel. *Latrobe Steel*

1371. Drill Rods
Large wall chart show flat ground tool steels and drill rods. *Uddeholm Co.*

1372. Ductile Iron
Reprints on engineering applications of ductile iron and its significance to the foundry industry. *Youngstown Foundry & Machine*

1373. Electric Furnaces
Booklet on electric furnaces with zone control between 500 and 2300° F. *L & L Mfg.*

1374. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1375. Electroforming
Bulletin on production of intricate parts and precision components by the electroforming process. *Bart Labs.*

1376. Electron Microscope
20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

1377. Electroplating
New bulletin on electroplating lists key characteristics of 16 processes. *Hanson-Van Winkle-Munning*

1378. Fabrication
46-page book shows metal fabrication and production facilities, products and services. *R. C. Mahon*

1379. Ferro-Alloys
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

1380. Freezers
Bulletins on environmental chambers from cold only to fully instrumentated all weather environmental installations. *Conrad, Inc.*

1381. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

1382. Finishing
Bulletin on buffs, compositions, brushes, polishing wheels and other equipment for mechanical finishing. *Hanson-Van Winkle-Munning*

1383. Finishing
Catalog of protective finishes and heat treating salts; rust preventives, blackening compounds. *Mitchell-Bradford*

1384. Finishing
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

1385. Finishing Barrels
12-page catalog of horizontal and tilting tumbling barrels. *Globe Stamping Div*

1386. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

1387. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g.*

1388. Flow Meters
24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

1389. Fluoroscopy
12-page booklet on fluoroscopy for nondestructive internal inspection. Explains image amplifier. *Westinghouse Electric, Industrial X-Ray Dept.*

1390. Forging Design
16 page book on design of forgings covers purpose, forging tools, design for drop forgings, press forging design, economy tips. *Globe Forge*

1391. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1392. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U.S. Steel*

1393. Foundry Refractories
30-page catalog of refractories for foundry use includes sections on cupola block manufacture, ladle refractories, slag and breast block, etc. *Laclede-Christy*

1394. Freezer
Data on chest for use down to −95° F. for production use and testing. *Revco*

1395. Fuel Gas
Bulletin on "Pyrofax" gas for cutting, brazing, metallizing, flame hardening, carburizing and heat treating. *Pyrofax Gas Co.*

1396. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

1397. Furnace Controls
22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

1398. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

1399. Furnace Maintenance
16-page "Maintenance Guide for Electric Heat Treating Furnaces" on preventive program. *Hevi Duty Electric*

1400. Furnaces
Bulletin 435 on furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell*

1401. Furnaces
12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

1402. Furnaces
44-page Catalog 112, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

1403. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

1404. Furnaces
Bulletin on reverberatory furnaces for aluminum, aluminum alloys and die casting metals. *Eclipse Fuel Eng.*

1405. Furnaces
Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

1406. Furnaces
Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

1407. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1408. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Eng'g.*

1409. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1410. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

1411. Furnaces, Heat Treating
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1412. Gamma Radiography
8-page catalog on gamma-ray radiography with radioactive cobalt 60 and iridium 192. *Mitchell Radiation Products*

1413. Gamma Radiography
Data file on equipment and sources for cobalt 60 radiography in industry. *Technical Operations*

1414. Gas Cutting
New 12-page booklet on use of oxy-acetylene in rolling mills for scarfing and oxygen cutting. *Air Reduction Sales*

1415. Gas Torches
New 36-page catalog covering complete line of torches and tips for oxyacetylene cutting and welding. *Air Reduction Sales*

1416. Gold Plating
Folder on salts for bright gold plating. Also lists equipment needed. *Sel-Rex*

1417. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

1418. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphite tool steel. *Timken*

1419. Grinding Samples
Bulletin on equipment for fine grinding of specimens with emery papers or wet silicon carbide papers or cloths. Hand and motor powered grinders. *Buehler*

1420. Grinding Wheels
New 52-page catalog on diamond grinding wheels and hones. Wheel markings, selection of wheels, standard shapes and suggestions on use. *Norton*

1421. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1422. Hard Surfacing
40-page hardfacing manual tells what metals can be hardfaced, how to select right hardfacing material, procedures and applications. *Haynes Stellite*

1423. Hardness Conversion
Wallet-size celluloid card gives hardness and tensile conversions. *International Nickel*

1424. Hardness Tester
13-page booklet on microhardness tester with optional Vickers or Knoop diamond. *Geo. Scherr*

1425. Hardness Tester
Bulletin 616 on new portable hardness tester. *Newage International*

1426. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1427. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

1428. Hardness Tester
Bulletin on Impressor portable hardness tester. *Barber-Colman*

1429. Hardness Tester
Bulletin on hardness tester for all regular and superficial Rockwell tests. *Kent Cliff Div., Torsion Balance Co.*

1430. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

1431. Hardness Testing
8-page catalog B-953 on principles and

standards of Brinell hardness testing, and types of machines. *Steel City Testing*

1432. Heat Resistant Alloy
10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

1433. Heat Resistant Finish
Bulletin 531 on silicone-base heat-resistant finish. *Midland Ind. Finishes*

1434. Heat Treating
Data on how to heat, quench, wash and temper automatically. *Metalwash Machinery*

1435. Heat Treating
Folder on "Facts and Figures on Heat Treating Costs." *Metal Treating Inst.*

1436. Heat Treating
Loose leaf data sheets on heat treating oils, salts, carburizing compounds. *Park Chemical*

1437. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1438. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1439. Heat Treating Compound
Data on dry powder coating for promoting smooth heat treated parts. *Parker Stamp Works*

1440. Heat Treating Costs
Sample form for computing the cost of heat treating. *ASM*

1441. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1442. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

1443. Heat Treating Pots
Bulletin No. 5 on eight types of heat and corrosion resisting alloy cast heat treating pots, tubs and carburizing boxes. *Standard Alloy*

1444. Heat Treating Stainless
84-page book on heat treating stainless steels, both martensitic and austenitic. *Republic Steel*

1445. Heat Treatment
Bulletin 200 on car hearth, rotary hearth, pit, roller hearth, belt, chain, pusher and "hi-head" furnaces. *R-S Furnace*

1446. Heating Elements
24-page book on electric heating elements for use up to 2800° F. *Norton*

1447. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

1448. High-Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

1449. High-Speed Steel
New bulletin on structure and properties of "desegatized" high speed tool steel. *Latrobe*

1450. High-Strength Steel
66-page catalog on properties of Mayari *R steel. Applications which take advantage of its wear and corrosion resistance. *Bethlehem Steel*

1451. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

1452. High-Temperature Alloy
"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

1453. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

1454. High-Temperature Belts
24-page bulletin on metal conveyor belts. *Wickwire Spencer*

1455. High-Vacuum Pumps
36-page Catalog 750 gives formulas, constants, conversions used in vacuum work, pump selection data. *Stokes*

1456. Hydraulic Presses
Bulletin 147, "Practical Facts About Hydraulic Presses", an informative guide for the user of all types and sizes of hydraulic presses. *Lake Erie Engineering*

1457. Hydrogen Atmosphere
Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to −70° F. *Baker & Co.*

1458. Indicating Controller
Bulletin F-6314 on Series 400 Capacitrols for indicating and controlling temperatures, voltages, current, speed and similar variables. *Wheelco*

1459. Induction Heat Control
Sheet 83 on miniature radiation-detecting temperature-measuring device for flame hardening and induction heating. *Minneapolis-Honeywell*

1460. Induction Heating
New 12-page bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

1461. Induction Heating
4-page brochure on high frequency induction heaters for heating to 3000° F. *Electric Arc, Inc.*

1462. Induction Heating
Bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forging, extrusion and rolling. *Loftus Eng'g*

1463. Induction Heating
Folders on electronic induction heating generators. Case histories. *Induction Heating*

1464. Induction Heating
40-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

1465. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1466. Induction Melting
Data on induction melting furnaces for aluminum, brass and copper. *Morrison Engineering*

1467. Industrial Fans
Catalogs on industrial fans with forward, backward or radial blades. High temperature fans. *Garden City Fan Co.*

1468. Inspection
8-page booklet on magnetic particle inspection and where it is applicable. *Magnaflux*

1469. Iron Powder
Bulletin on production of iron powder for flame cutting, scarfing, powder metallurgy, electronics and chemical applications. *Easton Metal Powder Co.*

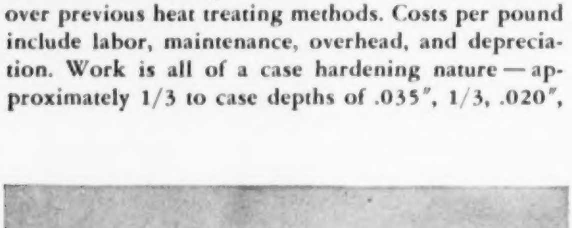
How Barmatic Products Co. Cut Heat Treating Costs 58%

WITH IPSEN AUTOMATIC CONTROLLED ATMOSPHERE UNITS

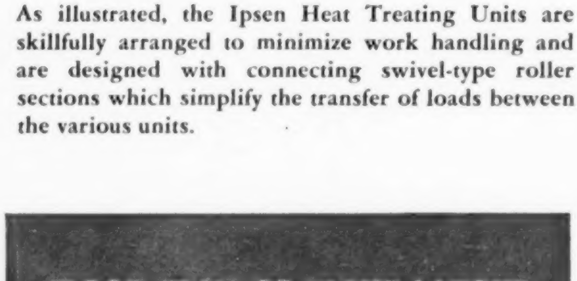
At Barmatic Products Company, Cleveland, Ohio, this modern 100% Ipsen-equipped department heat treats a fine quality line of automotive replacement parts. Starting with a Ipsen T-250 Unit two years ago, the department was quickly expanded and now includes an Ipsen Series T-400 Lb./Hr. Controlled Atmosphere Unit, a Controlled Atmosphere Tempering, and an Ipsen Washer Unit.

For the first five months of 1954, the records reveal this completely modernized heat treating department has effected an average net reduction in costs of 58.2% over previous heat treating methods. Costs per pound include labor, maintenance, overhead, and depreciation. Work is all of a case hardening nature — approximately 1/3 to case depths of .035″, 1/3, .020″, and the balance .005″ Over-all production records further reveal for this same period, 221,618 pounds have been processed, an average of 4,000 to 5,000 pounds each ten-hour day. Control of time, temperature, and atmosphere, coupled with straight-through batch processing features of Ipsen Automatic Units, are the important factors of this sizeable cost reduction. All work comes out bright and scale-free, and buffing and blasting operations are eliminated.

As illustrated, the Ipsen Heat Treating Units are skillfully arranged to minimize work handling and are designed with connecting swivel-type roller sections which simplify the transfer of loads between the various units.



TYPICAL RESULTS — C-1010 cold formed split bushings are now carbonitrided automatically without spring-back or opening of the seam during heat treating to case depths of .005/.007. 300-lb. loads are batch processed in 70 minute's total time.



1470. Joining Method
New bulletin on wire-wrap method of making solderless electrical connections. *Keller Tool Co.*

1471. Laboratory Furnaces
Information and bulletins available along with current price lists on complete assortment of Lindberg laboratory furnaces. *Boder Scientific Co.*

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8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

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Literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

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New catalog No. 460 on uses of colloidal graphite in industry. Table lists 40 basic dispersions of graphite. *Acheson Colloids*

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1489. Metal Cutting
Shop Notebook bulletin on control of vaporization of cutting fluid in metal cutting operations. *D. A. Stuart Oil*

1490. Metal Sorting
Data on nondestructive sorting tool for raw, semi-finished or finished parts. *Dice*

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Bulletin on new Reichert research metallograph which incorporates apparatus for testing surface finish, phase contrast metallurgy, macrophotography. *William J. Hacker*

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Chart of typical chemical analysis and commercial uses of zirconium oxides, silicates, soluble salts, metallurgical and foundry alloys. *Titanium Alloy Mfg.*

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Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

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38-page handbook on wire, rod, strip of Monel, Inconel, nickel and nickel-clad copper. *Alloy Metal Wire Co.*

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36-page Bulletin A-68 gives 70 mechanical property charts for various section sizes of nickel alloy steels. *International Nickel*

1499. Nickel Tubing
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6-page bulletin gives recommended design procedures on powder metal parts from ferrous and nonferrous metals. *Yale & Towne*

1514. Powder Metallurgy
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(Continued on page 32A)

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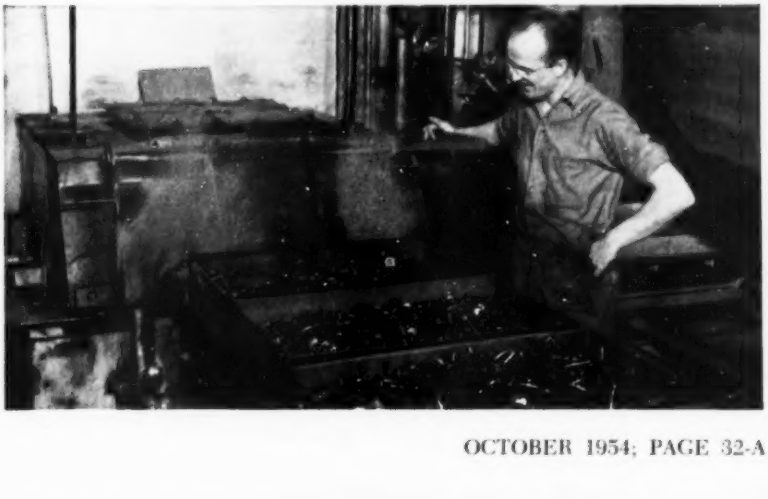

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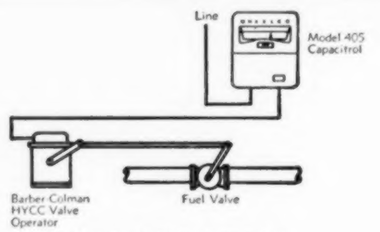

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72-page book on cleaning, preservation, and packaging of metals. Causes of corrosion. *E. F. Houghton*

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Use of vacuum metallizing in manufacture of plastic and metal parts. *National Research Corp.*

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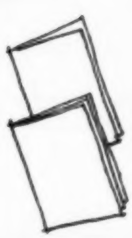

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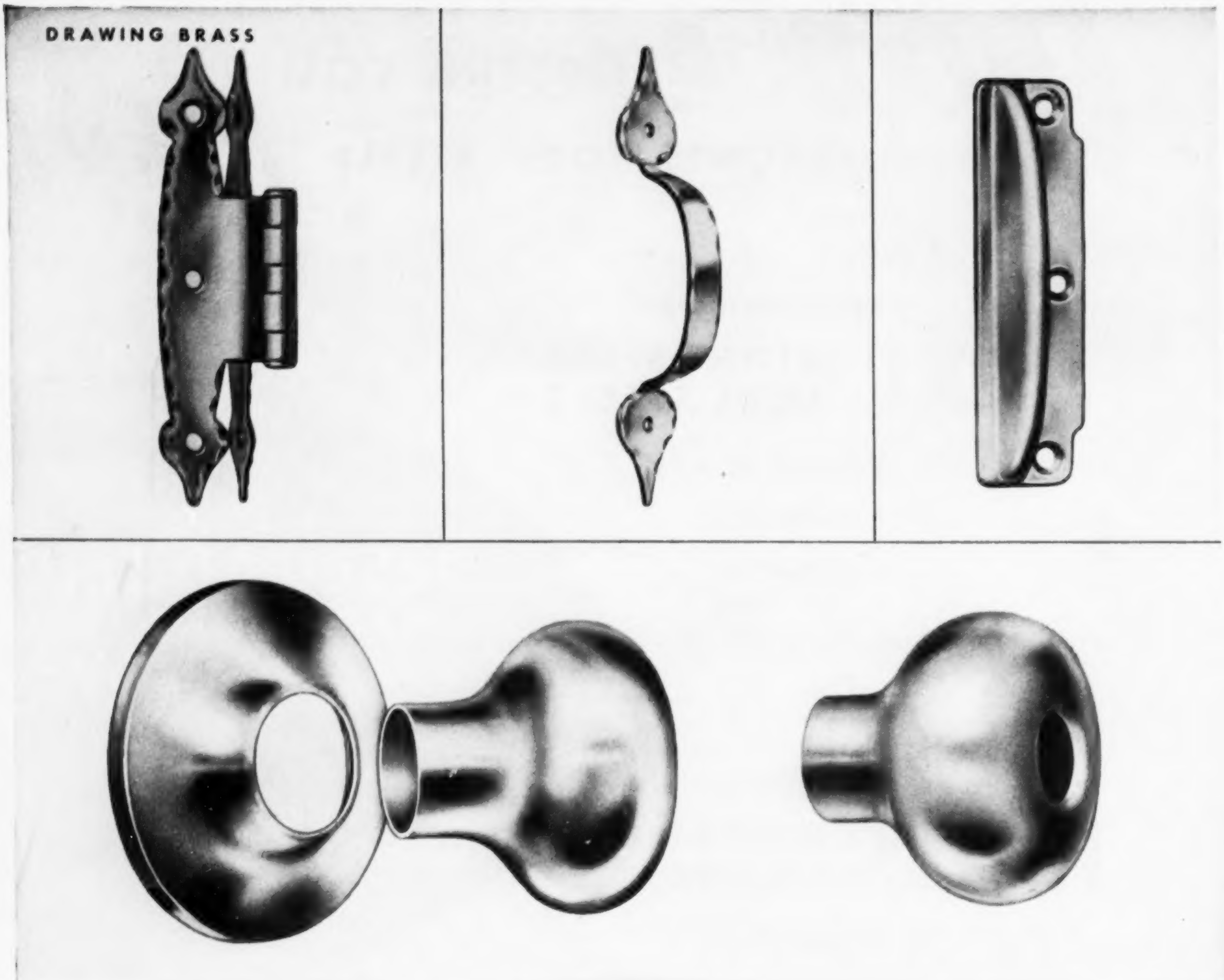
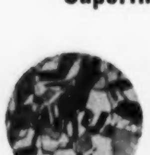


THESE HARDWARE ITEMS are made by Adams Rite Mfg. Co., Glendale, Cal., and National Lock Co. and American Cabinet Hardware Co., both of Rockford, Ill. They are typical of the stamped, drawn and pressed products

Formbrite—Anaconda's new drawing brass—polishes up to

Superfine grain makes Formbrite harder, stronger, springier and more scratch-resistant



75X magnification of ordinary drawing brass.

75X magnification of superfine-grain Formbrite.

Here is what enthusiastic manufacturers of stamped and drawn brass products say about *Formbrite:*

"... cuts our polishing costs up to 50% ... eliminates some finishing operations entirely ... gives amazingly sharp die impressions... resists scratching in handling ... plates beautifully ... gives a more lustrous finish ..."

Yet *Formbrite** costs no more than the ordinary drawing brasses these manufacturers had been using. In fact, Formbrite very often saves more than the metal itself costs.

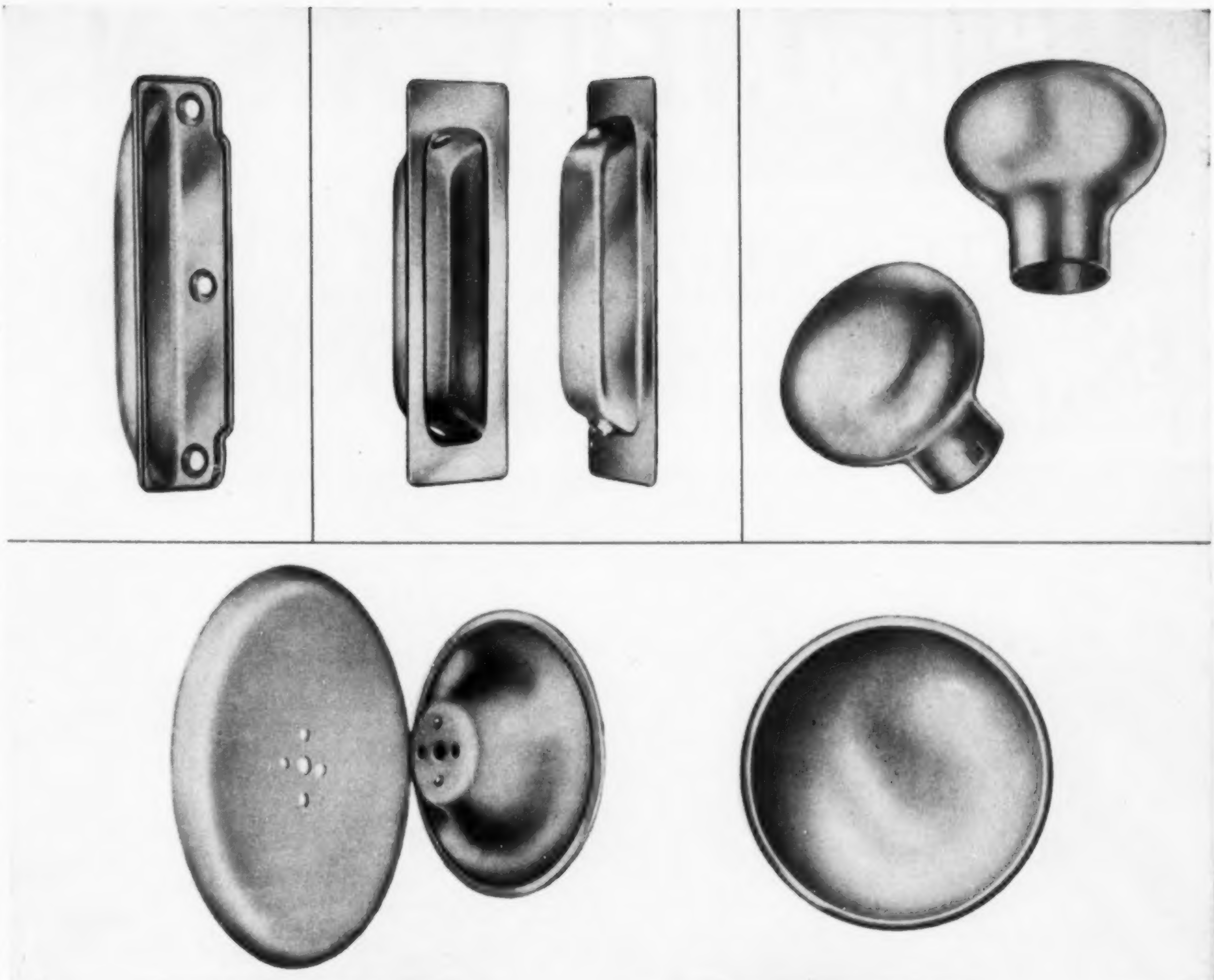
Why Formbrite is easier to use

Note Formbrite's superfine grain structure. Compare it with that of ordinary drawing brass. Special methods of rolling and annealing produce a grain structure so fine that often a simple color buff will bring it to a bright, lustrous finish.

Formbrite is also harder, stiffer, springier and more scratch-resistant ... yet it is surprisingly ductile, readily stamped, formed, drawn and embossed.

Typical case

The Adams Rite Mfg. Co. makes the flush pull shown in the upper right



successfully made of Formbrite. Others include: lipstick holders, fishing lures, automobile hubcaps, gage cases, trophy nameplates, pen caps, etc. (Doorknob parts in lower left illustration have been chromium plated.)

50% faster... costs no more than ordinary drawing brass

illustration above. For this and many other building hardware items, they use Formbrite. They report:

"Formbrite increases surface hardness and rigidity of the part . . .eliminates several polishing operations and reduces over-all costs. Our flush pull definitely has been improved in quality."

Free sample

Formbrite is available in sheet, strip and coils—in all commercial widths and gages. Millions of pounds of this superior drawing brass have been made, sold and satisfactorily fabricated.

Want more proof? Mail the coupon and we'll send you a sample of Formbrite. Try it in your polishing room. See for yourself how quickly and easily Formbrite polishes. 5498

*Reg. U. S. Pat. Off.

Formbrite

FINE-GRAIN DRAWING BRASS

AN ANACONDA* PRODUCT

MADE BY THE AMERICAN BRASS COMPANY

FREE SAMPLE—Test Formbrite Yourself

The American Brass Company, Waterbury 20, Connecticut

(In Canada: Anaconda American Brass Ltd., New Toronto, Ont.)

☐ Send me a free sample of Formbrite to try in my polishing room.

☐ Send me Publication B-39, giving formigg and finishing suggestions.

NAME ....

COMPANY ....

STREET ....

CITY .... ZONE ...... STATE ....

Delpark FILTRATION

AT

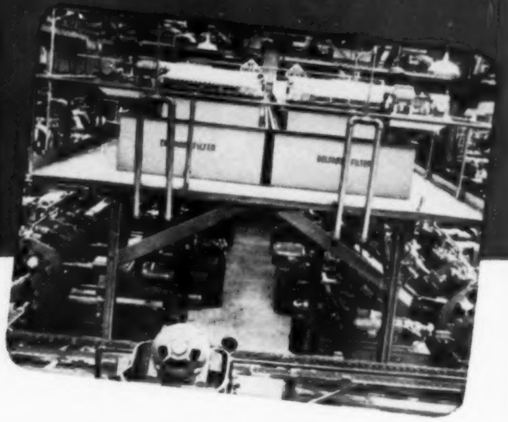
PRATT & WHITNEY AIRCRAFT

(DIVISION OF UNITED AIRCRAFT CORPORATION)

filters Aluminum Chips from Cutting Oil

Close up of DELPARK units filtering cutting oils from a battery of automatic Foothart Machines.

Illustration below shows same DELPARK installation in its position above the machines being served.



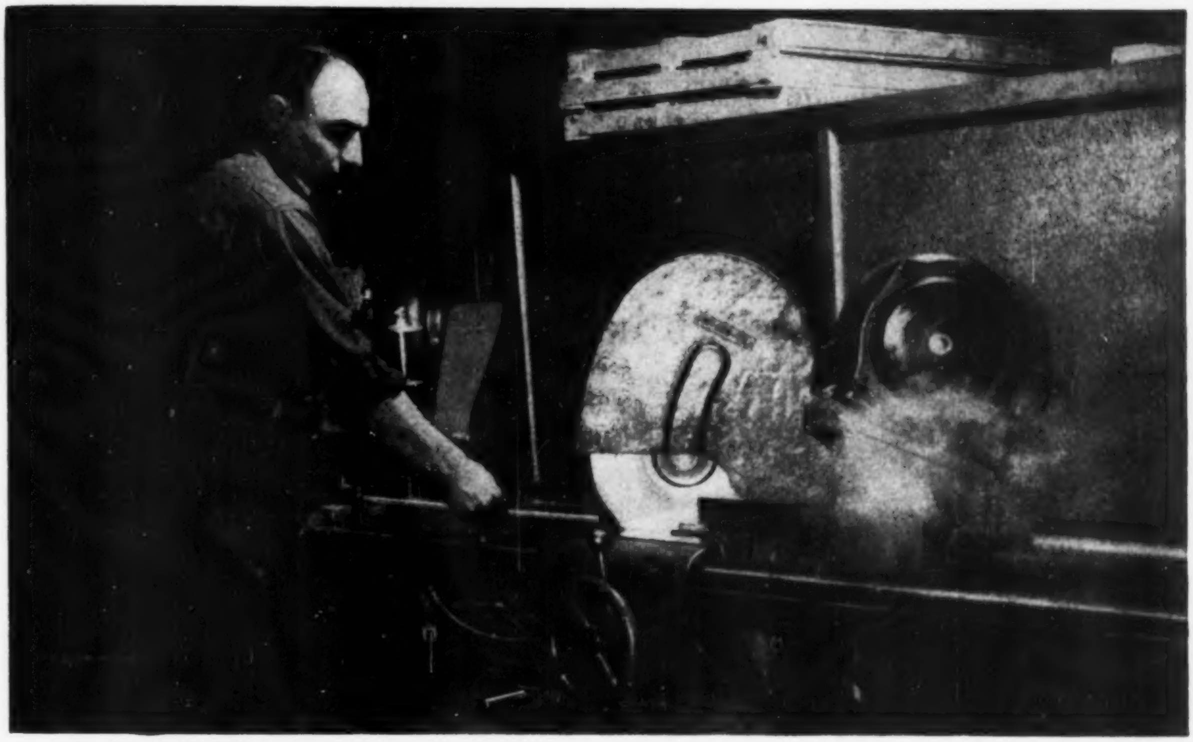
There are thousands of DELPARK Filters in industry today and the reasons for their acceptance are simple. The savings in maintenance labor alone is enormous yet other savings in reduced rejections, extended coolant and tool life and reduced machine parts replacements add up to even greater savings. Here is one part of production where costs can be materially reduced without retooling for design changes. Here, with DELPARK filtration, greater efficiency of men and machines can produce better products at less cost with greater accuracy.

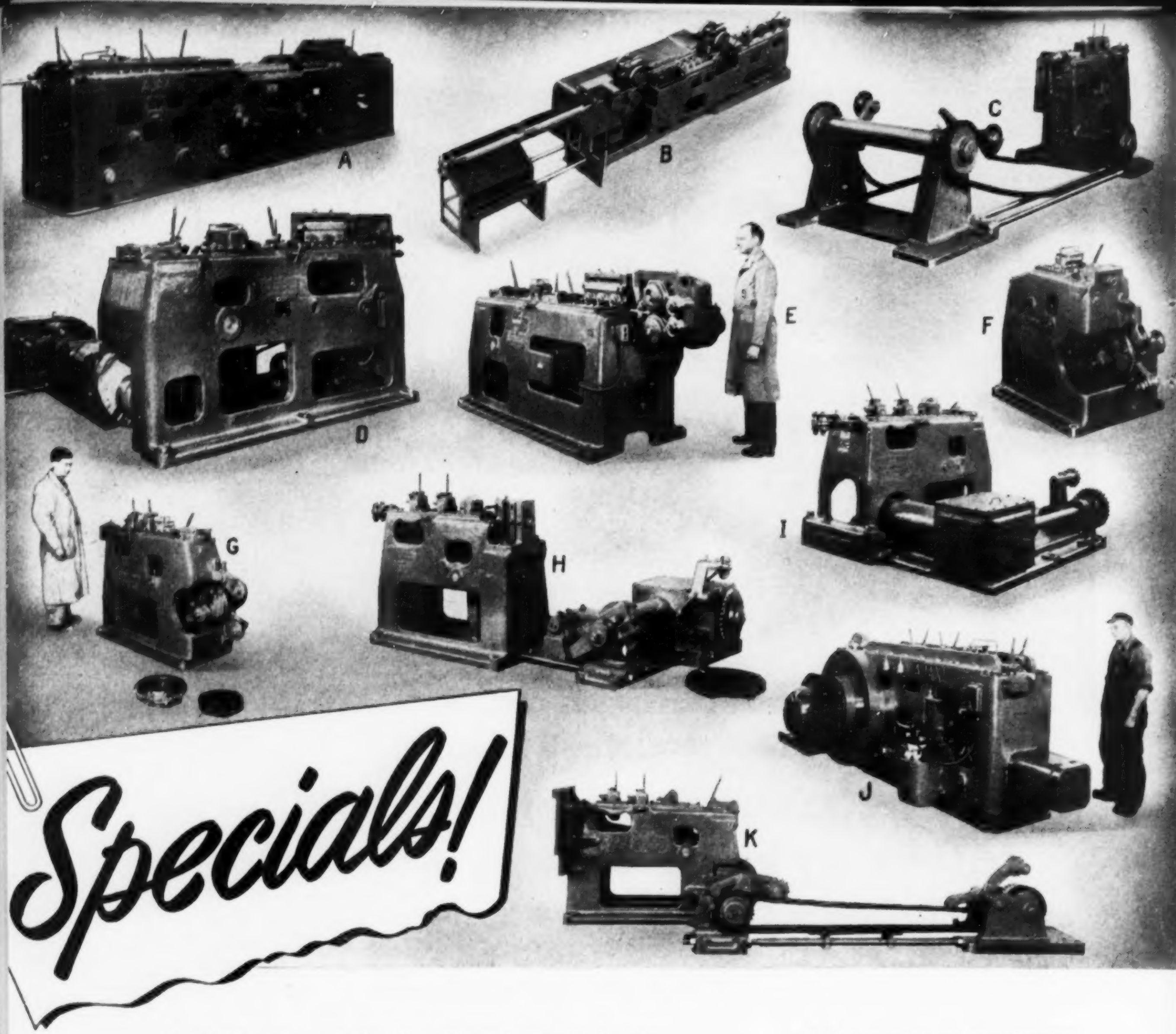
It's a simple operation to let DELPARK filtration lower your operating costs and increase your profits. Let an experienced DELPARK filtration engineer give you the facts on DELPARK filtration. *Write for more complete information.*

Delpark INDUSTRIAL FILTRATION

Backed by More than 30 Years Experience in Industrial Filtration

INDUSTRIAL FILTRATION COMPANY, 118 INDUSTRIAL AVENUE, LEBANON, INDIANA

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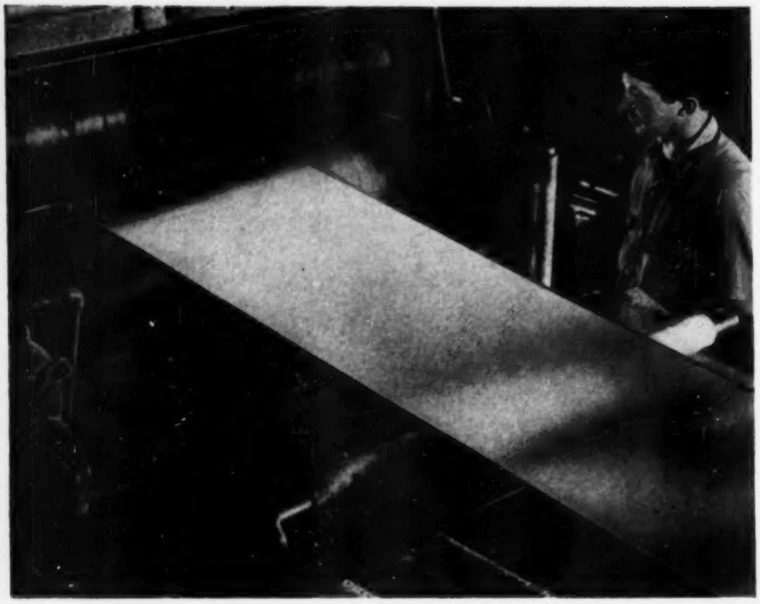
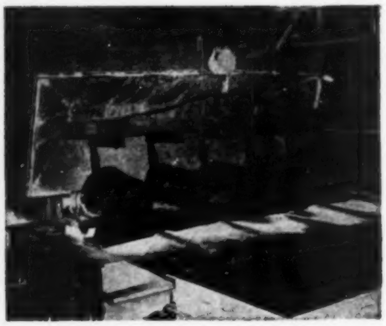
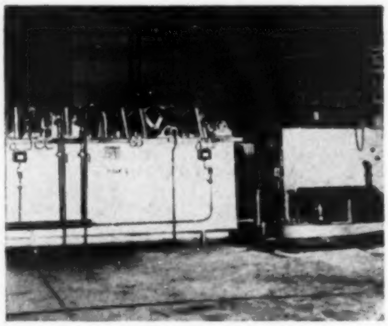
Specials!



TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.



10-MINUTE IMMERSION loosens scale on 5 tons of stainless wire. A water quench, 3-minute acid dip, and final water rinse produce a clean, bright surface with no pitting or etching.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.

Use this fast, safe Hooker Process for descaling steel and titanium

Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

A bath of molten Virgo Descaling Salt quickly converts scale, rust, and other surface impurities to an acid-soluble coating. A quench, acid dip, and final spraying then remove this coating in from one-tenth to one-hundredth the usual pickling time, with no measurable effect on the base metal.

You can easily set up the Hooker Process for batch or continuous operation on any form of work including strip, sheets, bars, wire, tubes, plate, castings, forgings, and fabricated parts. You can usually process work as fast as your handling methods allow, with a minimum of supervision. Operation is safe for personnel, and there is little or no spent-acid disposal problem.

You can profit by the experience of more than 50 companies now using the Hooker Process successfully to speed up descaling of alloy steels and titanium in practically every form.

You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.

Send for these bulletins—Get the whole story on Virgo Descaling Salt for alloy steels and titanium . . . how the Hooker Process works, its advantages, how to set up a Virgo descaling line, and the services you enjoy as a user. No obligation. Write us today.

From the Salt of the Earth

HOOKER CHEMICALS

HOOKER ELECTROCHEMICAL COMPANY
30 Forty-seventh Street, Niagara Falls, N. Y.
NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

4-1099

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

Keen Edges Hold on Blades of Lehigh H and L

The shear blades shown here are representative of the blades used in pairs in power squaring shears manufactured by Wysong & Miles Company, Greensboro, N. C. The blades are hollow ground, and are made of either Bethlehem Lehigh H or Lehigh L tool steel. They perform economically at speeds up to 60 strokes per minute because they hold their cutting edges for long periods of time, in this way minimizing the need for frequent regrinding.

Lehigh H and Lehigh L are high-carbon, high-chromium tool steels. They form high-chromium carbide concentrations, meaning the ultimate in wear. With its lower carbon content and addition of 1.00 pct nickel, Lehigh L has unusual toughness. It is used for shearing thicker material where shock is involved.

TYPICAL ANALYSES

	C	Cr	Mo	V	Ni
Lehigh H	1.55	11.50	0.80	0.40	—
Lehigh L	0.85	11.50	0.45	0.30	1.00

You can count on good wear-resistance with Lehigh H or Lehigh L. If you would like to have more information about these steels and their use, we suggest that you contact your tool steel distributor, or write direct to us at Bethlehem, Pa.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

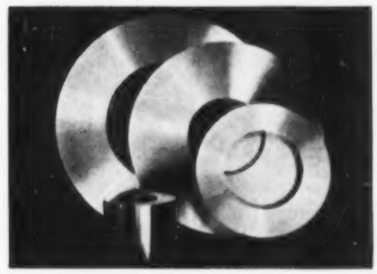
First Harden the Die, Then the Punch

In making up special punch-and-die sets, the fitting of the punch and die after hardening often involves hand grinding or stoning to remove the size changes produced during the hardening operation. The hole in the die will often close in, while the punch will usually expand in diameter. Thus the two parts will not fit, or will lose clearance.

In order to minimize such difficulties, and to reduce tool costs, the use of the following procedure is recommended:

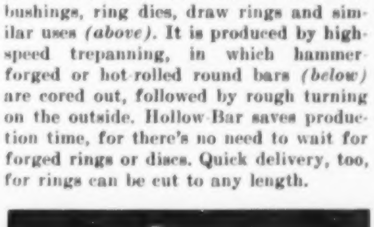
1. Make up the die, and harden it. 2. Make up the soft punch, and fit it to the die. 3. Harden punch. 4. If necessary, fit punch to die by grinding.

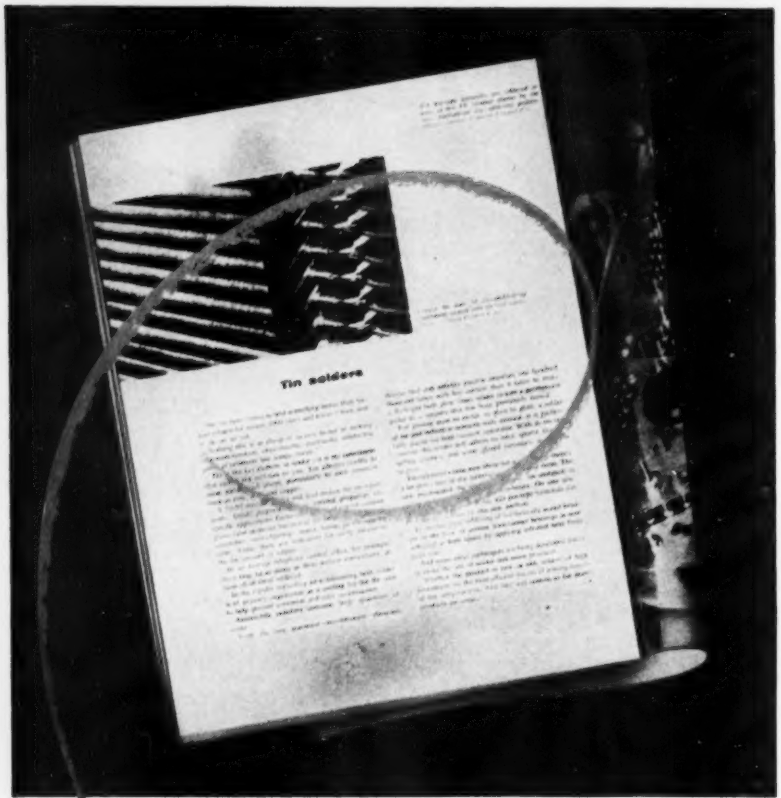
In this way, only one of the two parts is ground in the hardened condition, and the grinding is external and easier than internal grinding. To avoid excessive grinding, it may occasionally be advisable to allow for size-change in the die. But in the main this procedure can bring worthwhile economies.



HOLLOW-BAR TOOL STEEL IS IDEAL FOR RING-TYPE APPLICATIONS

BTR (Bethlehem Tool Room) Hollow-Bar is an excellent steel for hardened bushings, ring dies, draw rings and similar uses *(above)*. It is produced by high-speed trepanning, in which hammer-forged or hot-rolled round bars *(below)* are cored out, followed by rough turning on the outside. Hollow-Bar saves production time, for there's no need to wait for forged rings or discs. Quick delivery, too, for rings can be cut to any length.





NEW BOOKLET ON
STRAITS TIN FROM MALAYA

This new booklet describes the many ways Straits Tin—in new solders, new alloys, and new platings and coatings —is now being used to make better products at lower cost. It is factual, informative — and could well prove profitable to you. Write now for "Straits Tin: A Most Useful Metal for American Industry."

New Tin Alloys—New Techniques Make Soldering Faster, More Efficient

They've been using tin-rich solders for almost 2000 years — and haven't found a real substitute yet. Nothing else is as cheap or as easy to use in making corrosion resistant, impermeable, electrically conductive joints at relatively low temperatures.

Making Solder Still More Efficient

Now, new alloys and new soldering techniques are making tin solders still more useful on production lines.

A solder of tin-indium, for example, is now used for sealing glass to metal or glass to glass. It will adhere to mica, quartz, thermosetting plastics, and some glazed ceramics, as well.

For joining aluminum, cerium added to a tin-rich, tin-zinc solder gives both improved salt spray resistance and better wettability.

New techniques for applying solder include ultrasonic methods of soldering and tinning aluminum, and the new mechanized dip soldering process that is saving industry thousands of man-hours.

Tin is, of course, the key ingredient in solder. Over one-third of the world's tin is mined and smelted in Malaya. Known as Straits Tin, this metal is more than 99.87% pure and is world-famous for its absolute reliability of grade.

A New Look at Straits Tin

Today, not only new solders but new tin alloys, new tin-alloy coatings and platings, and new uses for tin chemicals make Straits Tin more valuable than ever to American industry. And continuing research will, in the near future, find still more ways in which tin can serve you.

Whatever your product or process may be, now is the time to reappraise carefully the unique combination of properties of Straits Tin. For no other metal we know today can do so many different kinds of jobs so economically and so well.

THE MALAYAN TIN BUREAU

Dept. 355, 1028 Connecticut Ave., Washington 6, D.C.

SWEDISH STEELMAKER STILL GOING STRONG

two basic resources: high-grade Swedish ore, over 200 years' experience

Uddeholm is one of Sweden's leading producers of fine steels. Although an iron works was set up at Uddeholm as early as 1668, the company got its real start in the 1700s. The growth that began then still continues. Today, Uddeholm owns mines, ferro alloy works, and modern mills, as well as power stations to run them and railroads to connect them.

Impressive, yes. But for the fine quality of Uddeholm steels two other factors are more important: the natural purity of the ore we use and the craftsmanship and skill acquired in over 10 generations of specialty steelmaking.

Uddeholm Swedish tool steels are marketed in the United States by the Uddeholm Company of America. Large stocks for all hot and cold work applications, in an unusually wide range of sizes, are carried in New York, Cleveland, and Los Angeles.

FREE—STOCK LIST OF UDDEHOLM TOOL STEELS

UDDEHOLM, 155 East 44th St., New York 17, N.Y.

Please send me________tool steel stock lists.

NAME ________________

TITLE ________________

COMPANY ________________

ADDRESS ________________

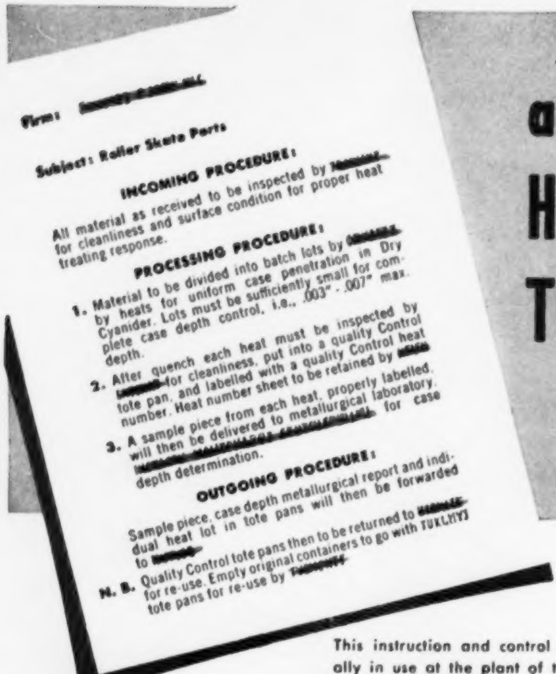
VISIT US, BOOTH 201, AT THE NATIONAL METAL EXPOSITION, CHICAGO, NOVEMBER 1ST TO 5TH.

UHB

UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Specialty Strip Steels

New York: 155 East 44th Street, MUrray Hill 7-4575
Cleveland: 3756 Carnegie Avenue, HEnderson 1-7440
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121


Firm: [redacted]

Subject: Roller Skate Parts

INCOMING PROCEDURE:

All material as received to be inspected by [redacted] for cleanliness and surface condition for proper heat treating response.

PROCESSING PROCEDURE:

1. Material to be divided into batch lots by [redacted] by heats for uniform case penetration in Dry Cyanider. Lots must be sufficiently small for complete case depth control, i.e., .003" - .007" max. depth.
2. After quench each heat must be inspected by [redacted] for cleanliness, put into a quality Control tote pan, and labelled with a quality Control heat number. Heat number sheet to be retained by [redacted]
3. A sample piece from each heat, properly labelled, will then be delivered to metallurgical laboratory, [redacted] for case depth determination.

OUTGOING PROCEDURE:

Sample piece, case depth metallurgical report and individual heat lot in tote pans will then be forwarded to [redacted]

N. B. Quality Control tote pans then to be returned to [redacted] for re-use. Empty original containers to go with [redacted] tote pans for re-use by [redacted]

This instruction and control sheet is actually in use at the plant of the commercial heat treater which solved a real problem for the manufacturer as told here.

an example of HOW COMMERCIAL HEAT TREATING CAN HELP YOU

Recently a manufacturer of roller skate parts encountered a great deal of difficulty in trying to find a source of heat treating for a particularly hard job. So serious was the problem that at one time consideration was given to installation of the necessary equipment at the manufacturer's plant. However, equipment would have cost over $20,000 plus the additional expense of labor, plant space, insurance, supplies, and above all, the metallurgical supervision required to control this intricate work properly.

The manufacturer turned to a local commercial heat treater to handle the work and even offered to install the required equipment. However, they were able to handle the job to the utmost satisfaction of the customer, using existing facilities.

The cyaniding operation involved required a case depth of 0.003" to 0.007". Samples of each batch processed are sent outside to a commercial metallurgical laboratory for inspection and testing. After OK, the parts and metallurgical report for each batch are shipped to the customer. The control sheet shown here is actually in use at the plant now doing the work and conveys some idea of the thoroughness to be expected from those commercial heat treating plants which are members of the Metal Treating Institute.

A reprint of the article, "Heat Treaters Cite Short Cuts to More Effective Purchasing" is available from each of the companies listed. This handy reference will prove of value when ordering heat treating.

THERE'S A HEAT TREATING SPECIALIST NEAR YOUR PLANT

Ace Heat Treating Company
Elizabeth, New Jersey

Anderson Steel Treating Co.
Detroit, Michigan

Benedict-Miller, Inc.
Lyndhurst, New Jersey

Commercial Metal Treating, Inc.
Bridgeport, Connecticut

Commercial Steel Treating Corp.
Detroit 4, Michigan

Cook Heat Treating Co. of Texas
Houston 11, Texas

The Dayton Forging & Heat Treating Co.
Dayton 3, Ohio

Dexter Metal Treating Co.
Oakland 21, California

Drever Company
Philadelphia 33, Pennsylvania

Greenman Steel Treating Company
Worcester 5, Massachusetts

Fred Heinzelman & Sons
New York 12, New York

Alfred Heller Heat Treating Co
New York 7, New York

Hollywood Heat Treating Co.
Los Angeles 38, California

L-R Heat Treating Company
Newark, New Jersey

The Lakeside Steel Improvement Co.
Cleveland 14, Ohio

Metallurgical, Inc.
Minneapolis 7, Minnesota

Metallurgical, Inc.
Kansas City 8, Missouri

Metlab Company
Philadelphia 18, Pennsylvania

Metro Heat Treating Corp.
New York 13, New York & Ridgefield, N.J.

O. T. Muehlemeyer Heat Treating Co.
Rockford, Illinois

New England Metallurgical Corp.
South Boston 27, Massachusetts

Paulo Products Company
Saint Louis 10, Missouri

Pittsburgh Commercial Heat Treating Co.
Pittsburgh 1, Pennsylvania

The Queen City Steel Treating Co.
Cincinnati 25, Ohio

J. W. Rex Company
Lansdale, Pennsylvania

Stanley P. Rockwell Company
Hartford 5, Connecticut

C. U. Scott & Son, Inc.
(Stainless Steels)
Rock Island, Illinois

Syracuse Heat Treating Corp.
Syracuse, New York

Temperature Processing Company, Inc.
North Arlington, New Jersey

Winton Heat Treating Company
Cleveland 16, Ohio

This advertisement sponsored by these Companies which are members of the Metal Treating Institute

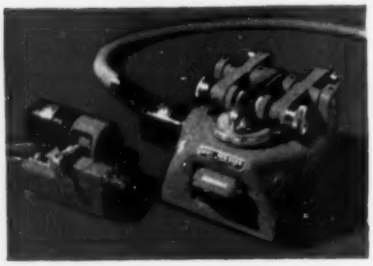
MTI MASTER CRAFTSMEN METAL TREATING INSTITUTE

Metal Progress

BULLETIN BOARD

THE BUYERS GUIDE FOR METALS ENGINEERS

Your LABORATORY CAN MAKE *Accurate* ABRASION RESISTANCE TESTS



with the TABER ABRASER

Simulates ACTUAL abrasion and wear conditions during test and gives ACCURATE numerical index for your report. Recognized the world over as the STANDARD for testing metals and metal finishes. The Abraser is now available in the NEW portable type Model 140-PT, illustrated above.

TABER STIFFNESS TESTER

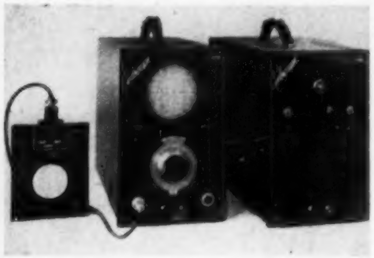
Determines both stiffness and resilience of sheet and wire specimens and gives report from DIRECT READING. No calculations!

Write for Illustrated Literature

Taber INSTRUMENT CORPORATION
SECTION 19
111 Goundry St., N. Tonawanda, N.Y.

LIST NO. 109 ON INFO-COUPON PAGE 64

It's Dice For The Best . . . in Metal Test Instruments



The CYCLOGRAPH (Model C) . . . for unscrambling metal mixups

This instrument permits truly high speed, non-destructive sorting of raw, semi-finished or finished parts by their metallurgical characteristics. With the new Automatic Sorter Unit speeds up to 300 pieces per minute are possible with the use of suitable feeding equipment. Used by leading industrial firms everywhere.

J. W. DICE CO., Englewood 3, New Jersey
"Non-destructive Testing and Measuring Instruments"

LIST NO. 50 ON INFO-COUPON PAGE 64

Inspection Demagnetizing or Sorting PROBLEMS?

SOLVED with

MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.
Over 50 steel mills and fabricators are now using this equipment.

MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETIC ANALYSIS COMPARATORS AND METAL TESTERS

Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

MAGNETIC ANALYSIS MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

For Details Write: "THE TEST TELLS"
MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 ON INFO-COUPON PAGE 64

ULTRASONICS

for rapid, accurate, non-destructive THICKNESS MEASUREMENTS from oneside and accelerated METAL CLEANING

VIDIGAGE Automatic Thickness Tester
Direct-Reading 21" Cathode-Ray Tube. Infinite Ranges 2:1, as selected, between 0.015" and 6" of steel or equivalent. Accuracy 0.1%—1.0% according to use.

AUDIGAGE® Portable Thickness Testers
Battery-Operated. Ranges 0.020"-4" and 0.060"-12" of steel or equivalent

SONOGEN Ultrasonic-Power Generator
for Metal Cleaning and other Industrial uses.

BRANSON INSTRUMENTS, inc. electronics development production
439 FAIRFIELD AVE · STAMFORD · CONN.

Literature on Request

LIST NO. 81 ON INFO-COUPON PAGE 64

Plan to Attend the

WESTERN METAL SHOW

Los Angeles
March 28 to April 1
1955

HERE'S HELP

for your engineer-recruitment problem

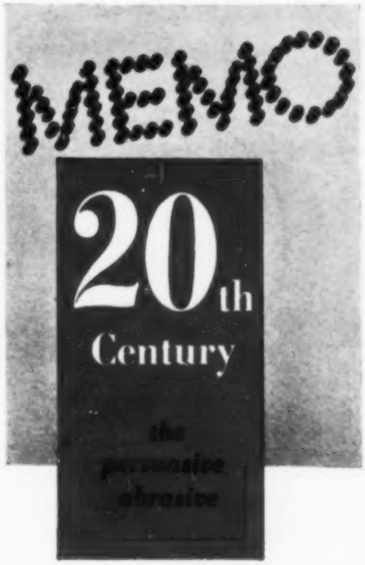
Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
5. It provides material that you can use in your own local and national programs.

Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

This space contributed by American Society for Metals



Make a mental note to specify 20th Century *Normalized shot or grit for your abrasive requirements. It's manufactured under close laboratory control to assure consistent high quality, greater uniformity, longer wear, and maximum production efficiency and economy.

Write for new catalog No. 1153.

THE CLEVELAND Metal Abrasive CO.

836 East 67th Street • Cleveland 8, Ohio
Howell Works: Howell, Michigan

*One of the world's largest producers of quality shot, grit and powder — Hard Iron — Malleable (*Normalized) — Cut Wire — Cast Steel (Realsteel)*

***Copyrighted trade name**

LIST NO. 2 ON INFO-COUPON PAGE 64

Prove it!

Prove to your own satisfaction that the MOLYKOTE line of industrial lubricants is one of the most spectacular contributions to metal progress in many decades. Send for free literature today and then order a trial supply.

MOLYKOTE®

INDUSTRY'S MOST VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.

Send for free catalog today!

THE ALPHA CORPORATION

LIST NO. 110 ON INFO-COUPON PAGE 64

WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3721 OAKWOOD AVE. · · YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 64

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

	(Please check)		
	Send Catalog or Engineering Data	Send Price Info	Nearest Source of Supply
(Bulletin Board Item Number)	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐
	☐	☐	☐

Your Name __________ **Title** __________
Company __________
Street __________
City __________ **Zone** _____ **State** _____

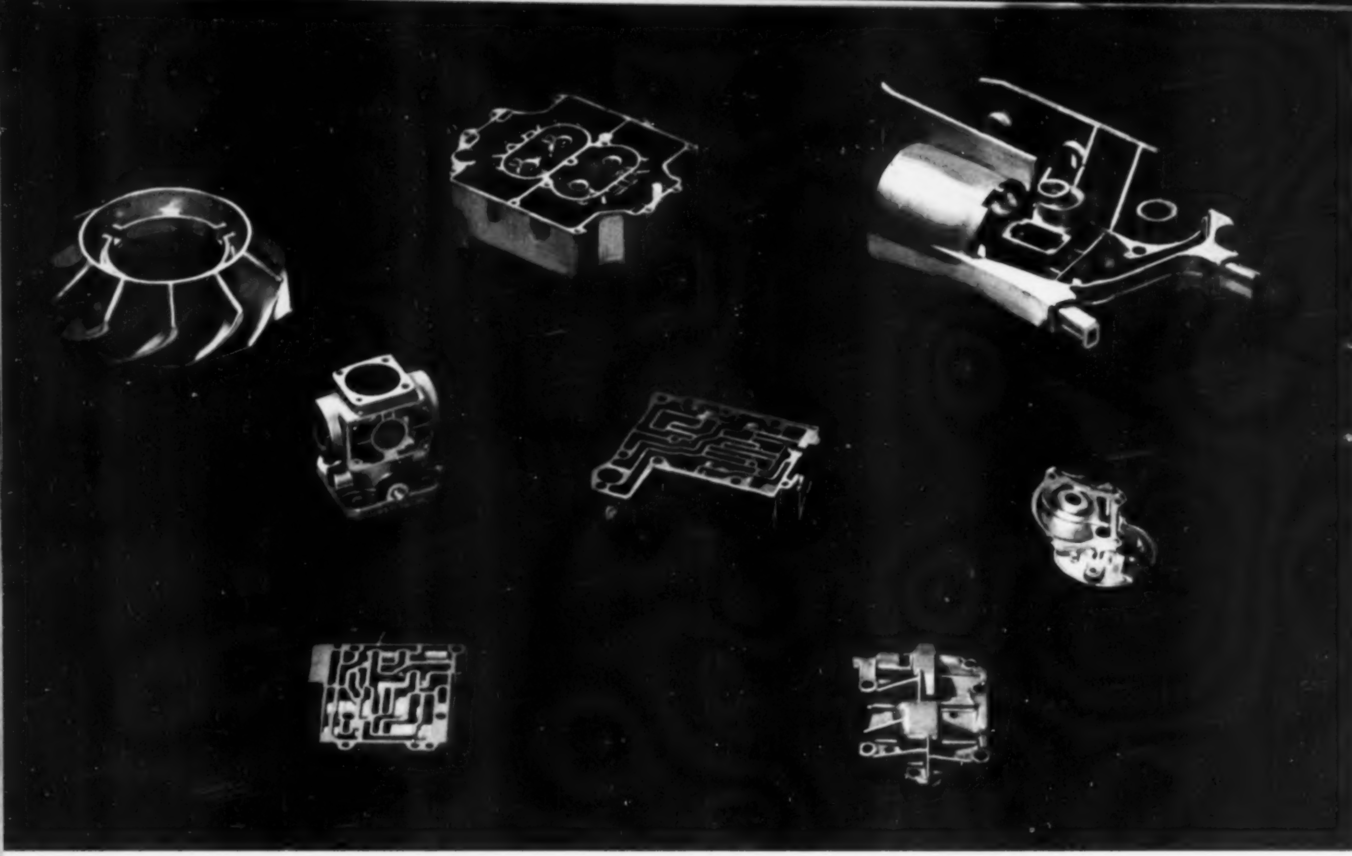
PRECISION DIE CASTINGS

can do this

FOR YOU

- **REDUCE COST** of component parts and end products.
- **REDUCE OR ELIMINATE ASSEMBLY COST** by combining several parts into one die casting.
- **REDUCE WEIGHT** of component parts and end products.
- **IMPROVE APPEARANCE** of your product.
- **IMPROVE PERFORMANCE** of your product.

HERE'S HOW . . .



COMPLICATED CORING

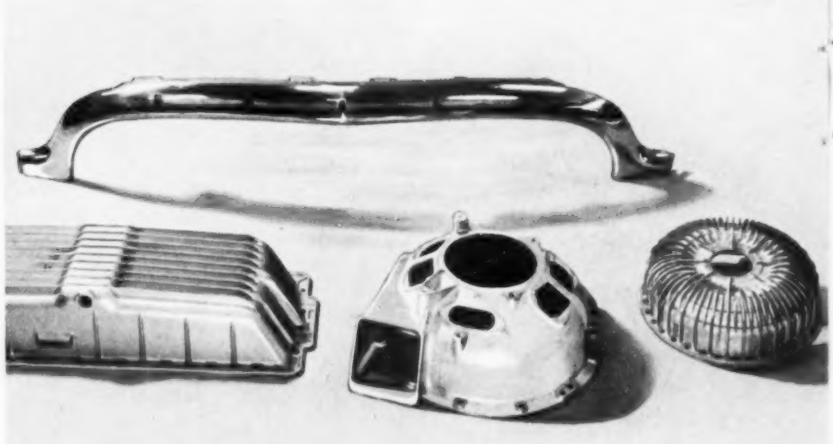
1. Reduces subsequent machining operations.
2. Combines several parts into one die casting.
3. Makes possible low-cost production of intricate parts in quantity.

EXTERNAL THREADS

1. Reduces subsequent machining operations.
2. Makes possible the use of many parts "as-cast."

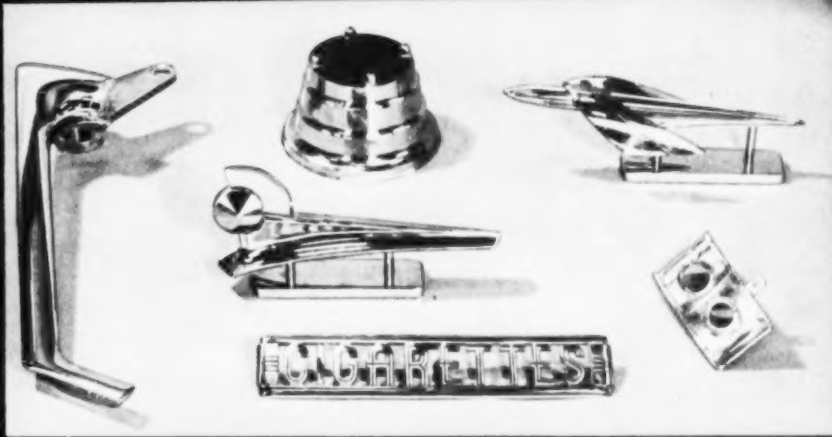
LARGE CASTINGS

1. Makes possible use of die castings for products which, if cast by other methods, would cost considerably more.
2. By proper design, can be made stronger and more rigid than by other production methods.
3. Makes possible the combining of several small parts, reducing or eliminating assembly costs.
4. Recent developments prove die castings by Precision can do tough jobs where functional stress is involved.



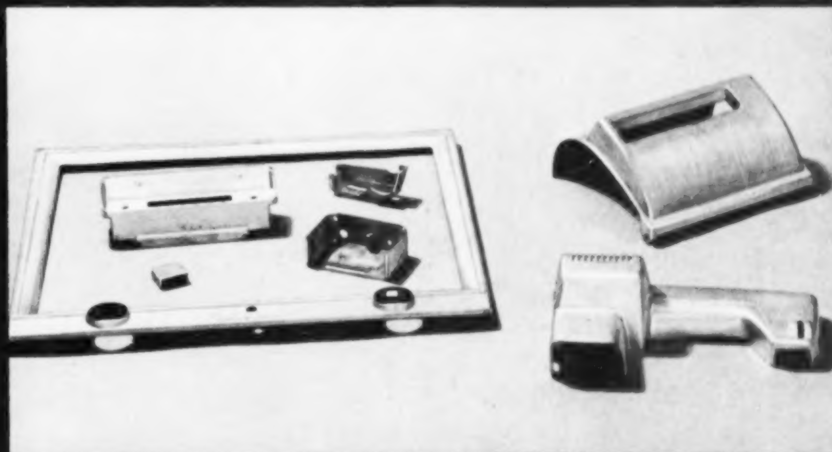
FINISHING

1. Many die castings, particularly aluminum, can be self finished. (e.g., Polished Aluminum)
2. Die castings can be painted, oxidized, plated or self finished by polishing.
3. Precision can finish in any manner including precious metal plating.
4. Precision has complete plating and finishing facilities at the Kalamazoo, Mich., and Syracuse, N. Y., plants.



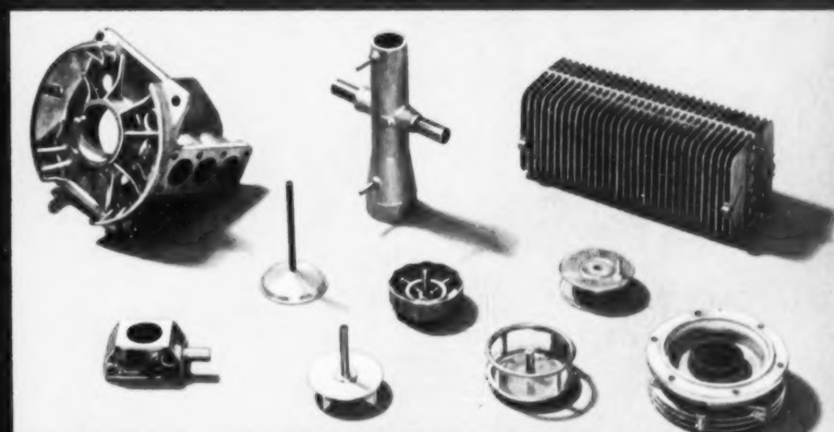
THIN SECTIONS

1. Makes possible the production of parts where rapid heat transfer or dissipation is important. Combined with high heat conductivity of aluminum, makes possible many products at low cost and greater efficiency.
2. Helps designer achieve weight reduction in product.
3. Reduces cost of many products as less metal is used.



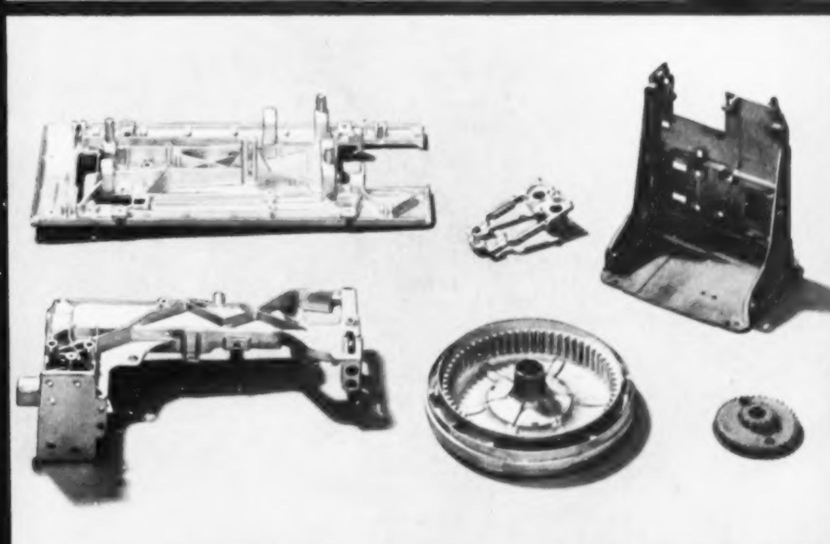
INSERTS

1. Inserts of any metal can be cast in die castings.
2. Makes possible the production of completely integrated parts — functional, electrical, structural, etc.
3. Inserts can be cast in for functional and ornamental purposes.



CLOSE TOLERANCES

1. Die castings can be produced to extremely close tolerances through rigid production control used at all of Precision's nine plants.
2. Many parts are cast to such close tolerances that they can be used "as-cast."
3. Precision's close control of tolerance often results in the substantial reduction or elimination of subsequent machining operations.
4. Very often this close control of tolerances reduces assembly time in your plant.




Pangborn

looking for

fast... low-cost *degreasing?*

Try **ALL-PURPOSE** Nialk® **TRICHLOR**ethylene

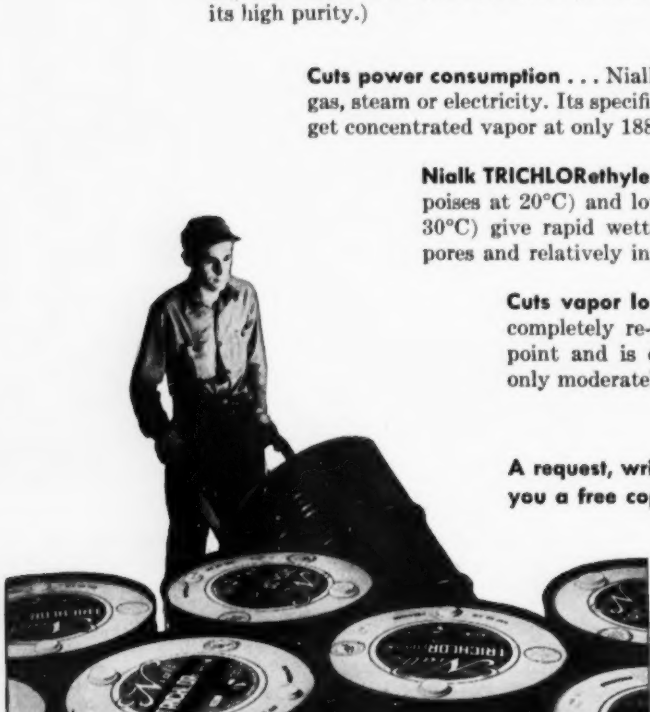
Here's an ideal organic solvent for removing practically every kind of foreign matter from metal parts. Whether it's waxes, oils, greases, tars or metal chips, you'll find that Nialk TRICHLORethylene does the job safely, thoroughly and economically, leaving parts clean, warm and dry, ready for immediate assembly, inspection or surface treatment.

Nialk TRICHLORethylene is quick acting . . . it cleans and dries rapidly. Its low boiling range (86.6–87.8°C, based on standard ASTM tests) permits vaporization at low steam pressure. (And that narrow boiling range reflects its high purity.)

Cuts power consumption . . . Nialk TRICHLORethylene can be heated by gas, steam or electricity. Its specific heat is less than ¼ that of water. You'll get concentrated vapor at only 188°F.

Nialk TRICHLORethylene is thorough . . . its low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) give rapid wetting of surfaces, plus thorough diffusion into pores and relatively inaccessible openings.

Cuts vapor loss . . . (its vapor density is 4.5 times that of air). It is completely re-usable after distillation, has no flash point, no fire point and is classed as nonflammable at room temperature and only moderately flammable at higher temperatures.



A request, written on your company letterhead, will bring you a free copy of our Nialk TRICHLORethylene booklet.

NIAGARA ALKALI COMPANY

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NIALK Liquid Chlorine • NIALK Caustic Potash • NIALK Carbonate of Potash
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Production savings with...

HUNTER DOUGLAS

VALVE SHOWN ACTUAL SIZE

COLD FORGING
FROM
HIGH STRENGTH ALUMINUM ALLOYS

The stress valve component pictured above was cold forged in seconds by Hunter Douglas to produce a solid blank ready for the secondary machining operations of slotting and tapping.

The valve was cold forged from a slug containing one-tenth the metal that would be required if the same part were machined from bar stock! Conserving metal for the strategic stockpile, eliminating costly machining operations, yet producing a stronger part faster, are only some of the advantages realized by this process.

Hunter Douglas Cold Forging gives a dense, non-porous grain structure that follows the contour of the part. The metal is uniformly distributed to bosses, lugs, recesses and other symmetrical projections without sacrificing strength and with minimum metal waste. Dimensional tolerances are held to extremely close limits, with draft-free surfaces for easier chucking and surface smoothness in the range of 32 to 125 micro-inches.

Combine the natural aluminum advantages of high-strength-weight-ratios, high thermal and electrical conductivity, good corrosion resistance and excellent machineability with this new mass production process and specify Hunter Douglas Cold Forging.

We invite your print for techincal advice and quotation. Literature available upon request.

write for free literature on your company letterhead **HUNTER DOUGLAS** *CORPORATION*

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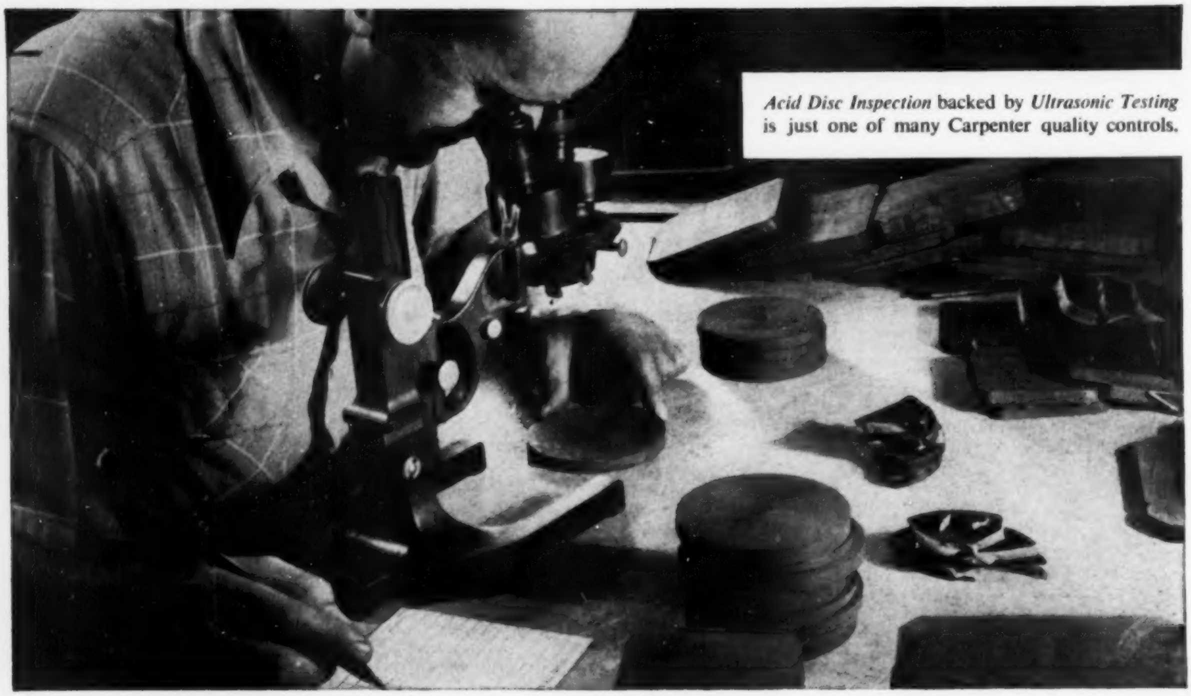

Acid Disc Inspection backed by *Ultrasonic Testing* is just one of many Carpenter quality controls.

IF YOU USE TOOL STEEL, THESE ARE FACTS YOU SHOULD KNOW

When you make or use a tool or die you invest a sizable sum of money. And there are steps you normally take to protect your investment. You make sure the design is right. You follow through with accurate toolmaking and correct heat treating. But there is *one* factor involved in the success of your die, over which you have only indirect control. That factor is the *soundness* of the die steel you start with. After all, if the steel itself isn't right, you needlessly risk your entire investment.

How can you be *sure* the die steel you use has what it takes to assure good tools? The answer lies in the painstaking controls regularly practiced by the steel manufacturer. Listed here are the four important tool steel controls pioneered by Carpenter to give steel users like yourself the protection you need. Before you place that next tool steel order, ask yourself, "Does our steel supplier guarantee these four quality controls in the die steel we use?" Then remember: You can be *sure* of them when you specify Carpenter Matched Tool and Die Steels. And you don't pay anything extra! THE CARPENTER STEEL COMPANY, 133 W. Bern St., Reading, Pa.

4 Tool and Die Steel Developments *Pioneered by Carpenter* Help Carpenter Customers Cut Costs, Improve Die Performance

Since 1929:
HOT ACID DISC INSPECTION has been standard practice at Carpenter. To Carpenter customers it provides full assurance that Matched Tool and Die Steels are internally sound, shipment after shipment.

Since 1930:
The **TOUGH TIMBRE TEST** has assured Carpenter users a wider safe hardening range, greater dependability in performance.

Since 1933:
The **TORSION IMPACT TEST** has provided Carpenter Matched Tool and Die Steel users with more complete heat treating information that leads to better tools and dies.

Since 1940:
The **CONE TEST**, used to check and control hardenability of Carpenter water-hardening Matched Tool and Die Steels, has made sure that sections of the same size have uniform hardness penetration in lot after lot.

Carpenter STEEL

Matched Tool and Die Steels

No. 610 · HAMPDEN · K-W · STAR-ZENITH
No. 484 · STENTOR · 11 SPECIAL · T-K
VEGA · R.D.S. · SOLAR · No. 883

Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U.S.A. and Canada


bright annealing
OF STAINLESS STEEL TUBING
at 2050°F
THESE ARE THE TWINS
The combination of the Drever TUBE TYPE BRIGHT ANNEALING FURNACE with extended water jacketed cooling chamber, and the Drever AMMONIA DISSOCIATOR provides the right way to BRIGHT ANNEAL STAINLESS STEEL AND INCONEL TUBING.
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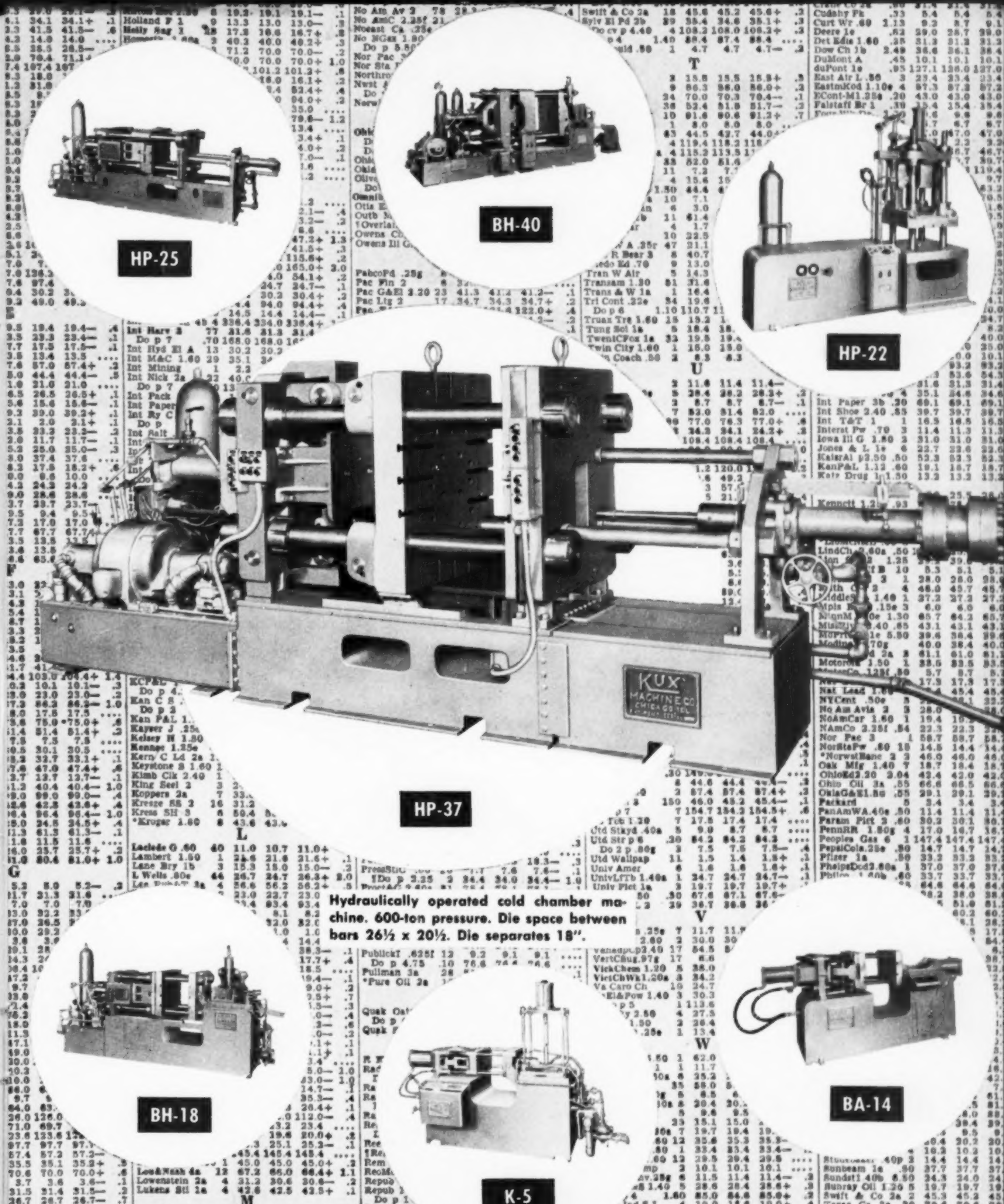
... here are the facts:
1—Fully Annealed
2—Absolutely Bright
3—No scale, oxides or scratches
4—No Carbide Precipitation
5—No pickling required before drawing
6—No pickling after finish anneal
7—Furnace can be gas or electrically heated
8—Capacities up to 2000 lbs./hour
9—Tubing from capillary size to 2½" O.D.
6


HP-25
BH-40
HP-22
KUX MACHINE CO. CHICAGO ILL.
HP-37
Hydraulically operated cold chamber machine. 600-ton pressure. Die space between bars 26½ x 20½. Die separates 18".
BH-18
K-5
BA-14
Just a few of the many hundreds of famous name users of Kux Die Casting Machines
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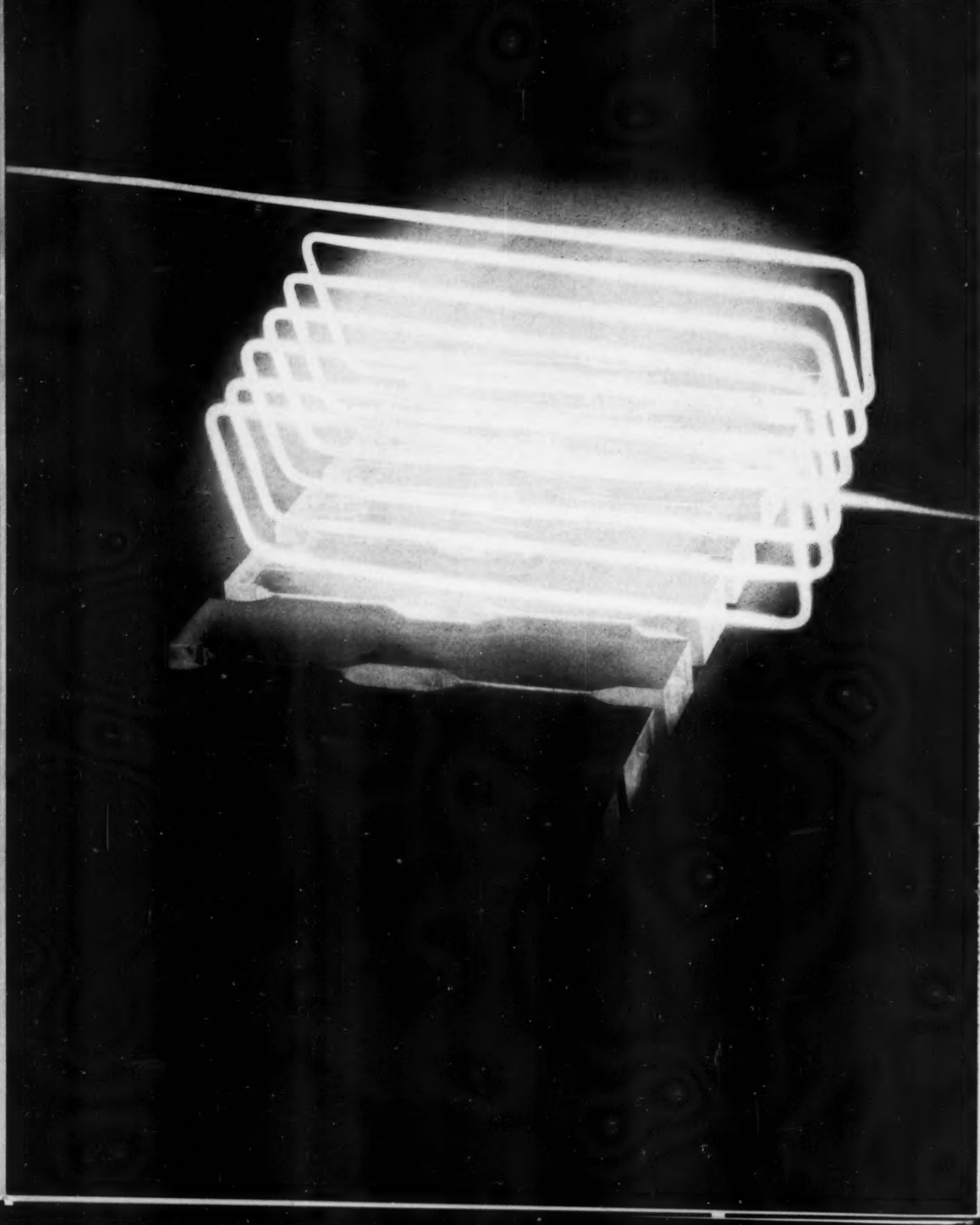


New Westinghouse coil design handles irregular shapes, puts forging operations into your production line

Another successfully applied Westinghouse development, this new technique brings the cost and production benefits of induction heating to a larger variety of forging operations than ever before.

Proved in actual service, this design solves the problems of heating a workpiece having an irregular cross section. It combines the *sideways feeding* of the workpiece with a specially developed inductor coil, and offers these outstanding advantages:

- Less space required—short inductor coil accommodates many workpieces side by side during heating cycle, yielding savings in production-line length and floor space.
- Heating uniformity—control of current flow in workpiece minimizes variations in heating normally caused by irregular contour.
- Greater efficiency—less exposed workpiece area means less radiation loss. Better coupling is possible on irregular-shaped workpieces.

This new process—as well as additional ones shown at right—offers greatly increased opportunity to cut costs, speed production and improve quality in your forging operation.

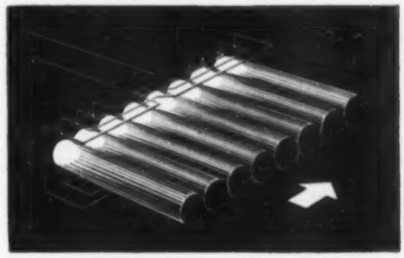
Put Westinghouse induction heating to work for you . . . NOW!

Whether your forging involves regular or irregular shapes, selective or over-all heating, Westinghouse can engineer and build the right and *complete* setup to solve your production problems. Call your local representative or write: Westinghouse Electric Corporation, Induction Heating Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

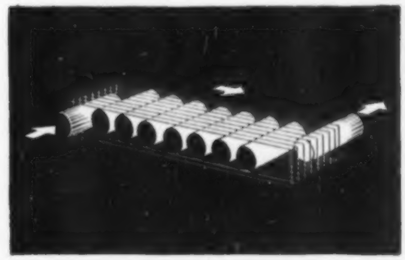
J-02288

YOU CAN BE **SURE**...IF IT'S
Westinghouse

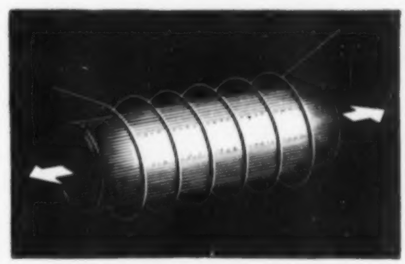
•Skilled application backed by long experience is the key factor in Westinghouse ability to make induction heating handle your individual problems. Below are three methods often used:



Lateral Feed—Bonnet Coil—Typical application: Heat 2 inches of the end of a 3/8-inch machine bolt blank to forging temperature at a production rate of 1750 pieces per hour. Adaptable to wide variety of shapes and sizes and "in-line" production.



Traverse Feed—In-Line Coil—Typical application: Through heat to forging temperature a 1 7/16-inch diameter, 13-inch long billet at a rate of 900 billets per hour. Gives maximum efficiency in heating long workpieces in greatly reduced floor space.



Coaxial Feed—In-Line Coil—Typical application: Through heat to forging temperature a 3 3/4-inch long, 2 1/2-inch diameter billet at a rate of 1440 billets per hour. After heating, piece may be retracted, or pushed straight through coil for "in-line" production.

INDUCTION HEATING FOR

HARDENING • JOINING • ANNEALING

FORGING • HEAT-TREATING

the "right" alloy steel that failed

A manufacturer wisely chose a certain alloy steel for key strength parts to avoid breakdown and the possibility of human injury. He specified an alloy that should have been right for the job. Yet, the "right" alloy failed. Why?

Since one alloy looks just like another, it might have been a case of mixed steels or it might have been poor response to heat treatment because of the variations that occur between different heats within the same specification. But here at Ryerson we have a plan to protect you from these hazards.

To avoid danger from mixed steels and to tell you exactly what to expect from heat treatment, Ryerson—and only Ryerson—puts every heat of alloy steel through 8 quality-control steps. Every heat is carefully selected, its anlysis verified and its hardenability established by a series of end-quench tests. Every bar is spark tested, positively identified with its own heat symbol and separately racked with other bars from the same heat. And finally, every shipment is carefully inspected and accompanied by a Ryerson Alloy Certificate which includes all test data to confirm analysis and guide heat treatment.

All this extra quality protection is provided by Ryerson at no extra cost to you. So to be sure of your alloy steel—sure of type and quality, sure of what the steel will safely do—call Ryerson for *Certified* Alloy Steel.

PRINCIPAL PRODUCTS

CARBON STEEL BARS—Hot rolled & cold finished

ALLOYS—Hot rolled, cold finished, heat treated

STAINLESS—Allegheny bars, plates, sheets, tubes, etc.

TUBING—Seamless & welded, mechanical & boiler tubes

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RYERSON CERTIFIED STEELS

RYERSON STEEL

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Metal Progress

Vol. 66, No. 4 November, 1954

As usual, the October issue of *Metal Progress* is devoted in large part to the forthcoming National Metal Congress and Exposition, to be held this year in Chicago the week of Nov. 1. (For early birds it really starts the previous Saturday morning with a scientific seminar, lasting through two meetings on Sunday, on "The Effect of Impurities and Imperfections on Metallic Properties".)

The 36th National Metal Exposition – the biggest ever – will open at Chicago's International Amphitheatre Monday noon, and be open daily until closing time, 6 p.m. Friday afternoon. The Amphitheatre is near the Stock Yards and most easily reached from any hotel in Chicago's Loop by State Street subway and Stockyards "L". Some 27 pages in this issue are devoted to a classification of exhibitors – what they will exhibit. Merely a glance through this array will convince any metals engineer that here is a showing of important new things which he can really use to advantage in his daily work. A visit – several visits – will richly repay in a harvest of ideas.

Several other national societies will supplement the A.S.M.'s own technical program with meetings of their own, making this indeed a Metal Congress. These five organizations will hold no less than 56 technical meetings at which 215 papers will be read and discussed, ranging over the whole field of metals, both scientific and practical, to say nothing of several honor lectures and panel discussions. Indeed the scope can only be appreciated by scanning the detailed program on pages 81 to 85. In addition, there is a course of three late-afternoon lectures on temperature measurement. Another feature will be three sessions in cooperation with the Industrial Heating Equipment Assoc. on furnace atmospheres, atmosphere applications and induction heat, matters which will be fully reported in the November issue of *Metal Progress*. The difficulty a visitor will have is in selecting what simply cannot be missed on this ample bill of fare.

Some innovations will be made in the more formal activities. The Annual Meeting will convene earlier (9 a.m. on Wednesday morning, Nov. 3) and numerous awards will be made in this session rather than at the Annual Banquet. The latter will thus have time for innovations which are intended to make it the sociable event of the year.

Come to Chicago for the Metal Show!

• CONSOLIDATED PROGRAM •

36th National Metal Congress

and National Metal Exposition

AMERICAN SOCIETY FOR METALS

INSTITUTE OF METALS DIVISION,

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS (A.I.M.E.)

AMERICAN WELDING SOCIETY (A.W.S.)

SOCIETY FOR NONDESTRUCTIVE TESTING (S.N.T.)

METALS DIVISION, SPECIAL LIBRARIES ASSOCIATION (S.L.A.)

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION (I.H.E.A.)

Saturday, Oct. 30, 1954

9:30 A.M., 2:00 P.M. Seminar: Impurities and Imperfections, Ballroom, Palmer House

Sunday, Oct. 31

9:30 A.M. and 2.00 P.M. Seminar: Impurities and Imperfections, Ballroom, Palmer House

4:30 P.M. A.I.M.E. Publications Committee Meeting, Morrison

8:00 P.M. A.I.M.E. Program Committee Meeting, Morrison

Monday, Nov. 1

8:00 A.M. S.N.T. Call to order and opening address, Morrison

9:00 A.M. S.N.T. Educational Program, Morrison

9:30 A.M. Constitution Diagrams, Ballroom, Palmer House

9:30 A.M. Laboratory Instruction in Process Metallurgy, Palmer House

9:30 A.M. A.I.M.E. Deformation, Ballroom, Morrison

9:30 A.M. A.I.M.E. Constitution, Cotillion Room, Morrison

10:00 A.M. A.W.S. Prize Awards, Louis XVI Room, Sherman

10:30 A.M. A.W.S. Adams Lecture, Louis XVI Room, Sherman

12:00 M. National Metal Exposition opens, International Amphitheatre

1:30 P.M. S.N.T. Educational Program, Morrison

2:00 P.M. Mechanical Metallurgy, Ballroom, Palmer House

2:00 P.M. Processing, Red Lacquer Room, Palmer House

2:00 P.M. A.W.S. Resistance Welding, Ballroom, Sherman

2:00 P.M. A.W.S. Weldability, Assembly Room, Sherman

2:00 P.M. A.I.M.E. Powder Metallurgy and Oxidation, Ballroom, Morrison

2:00 P.M. A.I.M.E. Diffusion, Cotillion Room, Morrison

4:30 P.M. Lecture Course on Temperature Measurement, Room 14, Palmer House

4:30 P.M. A.I.M.E. Membership Committee Meeting, Morrison

6:00 P.M. A.W.S. President's Reception, Crystal and Louis XVI Rooms, Sherman

8:00 P.M. A.W.S. National Dinner, Bal Tabarin, Sherman

8:00 P.M. A.I.M.E. Special Session on Metal Science, Ballroom, Morrison

10:30 P.M. National Metal Exposition closes

Tuesday, Nov. 2

9:00 A.M. S.N.T. General Session, Morrison

9:00 A.M. A.I.M.E. Third Annual Symposium on Titanium, Ballroom, Morrison

9:00 A.M. A.I.M.E. General Session, Cotillion Room, Morrison

9:30 A.M. Hardenability, Ballroom, Palmer House

9:30 A.M. A.W.S. Shielded-Arc Welding, Louis XVI Room, Sherman

9:30 A.M. A.W.S. Resistance Welding, Crystal Room, Sherman

9:30 A.M. A.W.S. Weldability, Assembly Room, Sherman

9:30 A.M. and I.H.E.A. Atmospheres, Red Lacquer Room, Palmer House

11:30 A.M. Canadian Fellowship Hour and Luncheon, Room 18, Palmer House

12:00 M. National Metal Exposition opens, International Amphitheatre

12:00 M. Battelle Alumni Luncheon, Room 17, Palmer House

12:30 P.M. A.I.M.E. Executive Committee Luncheon, Morrison

2:00 P.M. Physical Metallurgy, Ballroom, Palmer House

2:00 P.M. A.I.M.E. Third Annual Symposium on Titanium, Ballroom, Morrison

2:00 P.M. A.I.M.E. Phase Transformations and Recrystallization, Cotillion Room, Morrison

2:00 P.M. A.W.S. Section Officers Meeting, Crystal Room, Sherman

2:00 P.M. A.W.S. Weldability, Assembly Room, Sherman

2:00 P.M. A.W.S. Surfacing, Louis XVI Room, Sherman

2:00 P.M. S.N.T. Nondestructive Testing Abroad, Morrison

2:00 P.M. and I.H.E.A. Atmosphere Applications, International Amphitheatre

4:00 P.M. A.I.M.E. Nuclear Metallurgy Committee Meeting, Morrison

4:30 P.M. Lecture Course on Temperature Measurement, Room 14, Palmer House

6:00 P.M. A.I.M.E. Cocktail Party, Embassy Room, Morrison

7:00 P.M. A.I.M.E. Annual Fall Dinner, Cotillion Room, Morrison

10:30 P.M. National Metal Exposition closes

Wednesday, Nov. 3

7:45 A.M. Chapter Chairmen's Breakfast, Crystal Room, Palmer House

8:30 A.M. Industrial Gas Breakfast, Palmer House

9:00 A.M. Annual Meeting, Ballroom, Palmer

9:00 A.M. S.N.T. Ultrasonics, Morrison

9:30 A.M. A.W.S. Aircraft and Rocketry, Crystal Room, Sherman

9:30 A.M. A.W.S. Titanium, Zirconium and Molybdenum, Louis XVI Room, Sherman

9:30 A.M. A.W.S. Inert-Arc Welding, Assembly Room, Sherman

9:30 A.M. S.L.A. Field Trip to John Crerar Library

10:30 A.M. Campbell Memorial Lecture, Ballroom, Palmer House

12:00 M. National Metal Exposition opens, International Amphitheatre

12:00 M. Alumni Luncheons, Palmer House

2:00 P.M. Mechanical Properties, Ballroom, Palmer House

2:00 P.M. Ferrous Physical Metallurgy, Red Lacquer Room, Palmer House

2:00 P.M. A.I.M.E. Titanium, Ballroom, Morrison

2:00 P.M. A.I.M.E. Creep, Cotillion Room, Morrison

2:00 P.M. A.W.S. Pressure Vessels and Piping, Assembly Room, Sherman

2:00 P.M. A.W.S. Brazing, Crystal Room, Sherman

2:00 P.M. A.W.S. Symposium on Fused Metallized Coatings, Louis XVI Room, Sherman

2:00 P.M. S.N.T. Presentation of Awards and Mehl Honor Lecture, Morrison

2:00 P.M. and I.H.E.A. Induction Heat, International Amphitheatre

4:30 P.M. Lecture Course on Temperature Measurement, Room 14, Palmer House

6:30 P.M. A.W.S. WRC University Dinner, Emerald Room, Sherman

6:30 P.M. S.L.A. Illinois Chapter Dinner Meeting, Chicago Bar Association

8:00 P.M. A.W.S. WRC University Conference, Crystal Room, Sherman

9:00 P.M. S.N.T. Social Hour, Morrison

10:30 P.M. National Metal Exposition closes

Thursday, Nov. 4

9:00 A.M. S.N.T. Nondestructive Testing as Applied to Airline, Railway, Oil and Shipbuilding, Morrison

9:30 A.M. Stainless, Ballroom, Palmer House

9:30 A.M. Heat Treatment, Red Lacquer Room, Palmer House

9:30 A.M. A.W.S. Aircraft, Crystal Room, Sherman

9:30 A.M. A.W.S. Design and Production, Assembly Room, Sherman

9:30 A.M. A.W.S. Cutting, Ballroom, Sherman

9:30 A.M. S.L.A. The Small Metallurgical Library, Conrad Hilton Hotel

10:00 A.M. National Metal Exposition opens, International Amphitheatre

10:00 A.M. A.W.S. Board of Directors Meeting, Jade Room, Sherman

10:00 A.M. Midwest Industrial Gas Council, La-Salle Hotel

2:00 P.M. High Temperature, Red Lacquer Room, Palmer House

2:00 P.M. A.W.S. Business Meeting, Crystal Room, Sherman

2:00 P.M. S.L.A. Economics and Marketing in the Metallurgical Field, Conrad Hilton Hotel

6:00 P.M. National Metal Exposition closes

6:30 P.M. Cocktail Hour, Foyer, Ballroom, Palmer House

7:30 P.M. Annual Banquet, Ballroom, Palmer

10:30 P.M. Dancing, Red Lacquer Room, Palmer House

Friday, Nov. 5

9:00 A.M. S.L.A. Field Trip to Inland Steel Co.

9:30 A.M. A.W.S. Structural, Ballroom, Sherman

9:30 A.M. A.W.S. High-Temperature Materials, Assembly Room, Sherman

9:30 A.M. A.W.S. Applications, Old Chicago Room, Sherman

10:00 A.M. National Metal Exposition opens, International Amphitheatre

12:00 M. Distinguished Service Luncheon for 25-Year Members and Students, Saddle and Sirloin Club, Stock Yards

6:00 P.M. National Metal Congress and National Metal Exposition end

American Society for Metals

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J. MITCHELL WATSON	1931	BRADLEY STOUGHTON	1942	JAMES B. AUSTIN	1954
		HERBERT J. FRENCH	1943		

SECRETARY

WILLIAM H. EISENMAN 1920—

FOUNDER MEMBERS

†T. E. BARKER — †A. C. HENRY — WM. H. EISENMAN — WM. P. WOODSIDE — A. E. WHITE

HONORARY MEMBERS

†CHARLES F. BRUSH	BENJAMIN F. FAIRLESS	†HENRY MARION HOWE	ALBERT PORTEVIN
†EDWARD DeMILLE CAMPBELL	†ELBERT H. GARY	AXEL HULTGREN	†ALBERT SAUVEUR
†HENRY LE CHATELIER	†SIR ROBERT HADFIELD	ZAY JEFFRIES	†CHARLES M. SCHWAB
CECIL H. DESCH	†ELWOOD HAYNES	CHARLES F. KETTERING	BRADLEY STOUGHTON
†THOMAS ALVA EDISON	†KOTARO HONDA	†JOHN ALEXANDER MATHEWS	A. E. WHITE
			WILLIS R. WHITNEY

SAUVEUR ACHIEVEMENT MEDALISTS

†ALBERT SAUVEUR	1934	†ALBERT L. MARSH	1941	†M. A. GROSSMANN	1949
ZAY JEFFRIES	1935	BENJAMIN F. SHEPHERD	1942	CLARENCE E. SIMS	1950
WILLIAM R. CHAPIN	1936	†CHARLES H. HERTY, JR.	1943	ROBERT F. MEHL	1951
HARRY W. McQUAID	1938	WALTER E. JOMINY	1944	JOHN CHIPMAN	1952
†STANLEY P. ROCKWELL	1939	ROBERT S. ARCHER	1945	WILLIAM T. ENNOR	1953
A. W. MACHLET	1940	EDGAR C. BAIN	1946	ALEXANDER L. FEILD	1954
		F. P. ZIMMERLI	1947		

HENRY MARION HOWE MEDALISTS

E. J. JANITZKY	1922	MAXWELL GENSAMER	1932	†M. A. GROSSMANN	1941	W. A. PENNINGTON	1947
FRANCIS F. LUCAS	1924	JOHN F. ECKEL	1932	MORRIS ASIMOW	1941	J. W. SPRETNAK	1948
HORACE H. LESTER	1925	JOSEPH V. EMMONS	1933	S. F. URBAN	1941	B. L. AVERBACH	1949
†F. C. LANGENBERG	1926	JOHN CHIPMAN	1934	W. A. SCHLEGEL	1942	W. O. BINDER	1950
WESLEY P. SYKES	1927	†T. D. YENSEN	1935	SHADBURN MARSHALL	1943	C. M. BROWN	1950
OSCAR E. HARDER	1928	NICHOLAS A. ZIEGLER	1935	R. A. FLINN	1944	RUSSELL FRANKS	1950
RALPH L. DOWDELL	1928	A. G. H. ANDERSEN	1937	EARNSHAW COOK	1944	B. J. LAZAN	1951
†C. R. WOHRMAN	1929	ERIC R. JETTE	1937	J. A. FELLOWS	1944	E. M. MAHLA	1952
H. J. FRENCH	1930	JOSEPH WINLOCK	1938	DARA P. ANTIA	1945	N. A. NIELSEN	1952
EDGAR C. BAIN	1931	R. W. E. LEITER	1938	S. G. FLETCHER	1945	L. F. PORTER	1953
KARL HEINDLHOFER	1931	C. S. BARRETT	1939	MORRIS COHEN	1945	P. C. ROSENTHAL	1953
FRANCIS M. WALTERS	1932	GERHARD ANSEL	1939	CHARLES R. AUSTIN	1946	H. J. BEATTIE, JR.	1954
CYRIL WELLS	1932	ROBERT F. MEHL	1939	MAURICE C. FETZER	1946	F. L. VerSNYDER	1954

THE GOLD MEDAL OF THE AMERICAN SOCIETY FOR METALS

ZAY JEFFRIES	1943	C. H. MATHEWSON	1947	EDGAR C. BAIN	1949	ROBERT F. MEHL	1952
EARLE C. SMITH	1945	F. C. FRARY	1948	PAUL D. MERICA	1951	GEORGE SACHS	1953

THE A.S.M. MEDAL FOR THE ADVANCEMENT OF RESEARCH

ROY A. HUNT	1943	R. E. ZIMMERMAN	1946	FRED H. HAGGERSON	1949	CLEO F. CRAIG	1952
†ROBERT C. STANLEY	1944	C. R. HOOK	1947	CHARLES E. WILSON	1950	H. G. BATCHELLER	1953
GERARD SWOPE	1945	†W. H. DOW	1948	GWILYM A. PRICE	1951	WILLIAM E. UMSTATTD	1954

CAMPBELL MEMORIAL LECTURERS

WILLIAM M. GUERTLER	1926	JAMES P. GILL	1936	MAXWELL GENSAMER	1945
ZAY JEFFRIES	1927	WESLEY P. SYKES	1937	JAMES B. AUSTIN	1946
†W. H. HATFIELD	1928	ALFRED L. BOEGEHOLD	1938	A. B. KINZEL	1947
†ALBERT SAUVEUR	1929	EDMUND S. DAVENPORT	1939	MORRIS COHEN	1948
†MARCUS A. GROSSMANN	1930	SAMUEL L. HOYT	1940	EDGAR H. DIX, JR.	1949
†CHARLES H. HERTY, JR.	1931	ROBERT F. MEHL	1941	EARLE C. SMITH	1950
EDGAR C. BAIN	1932	JOHN CHIPMAN	1942	C. H. LORIG	1951
HERBERT J. FRENCH	1933	C. H. MATHEWSON	1943	CYRIL STANLEY SMITH	1952
VSEVOLOD N. KRIVOBOK	1934	GEORGE R. FITTERER	1944	DONALD S. CLARK	1953
HARRY W. McQUAID	1935			KENT R. VAN HORN	1954

†Deceased

Technical Program

Seminar on Impurities and Imperfections

All Meetings in Ballroom, Palmer House, Chicago

Saturday, Oct. 30

9:30 A.M.—First Session

Lattice Vacancies and Interstitials
by *Harvey Brooks*, Harvard University

Dislocations
by *J. C. Fisher*, General Electric Co.

Grain Boundaries, Substructure and Impurities
by *R. W. Cahn*, University of Birmingham, England (Visiting Lecturer, Johns Hopkins University)

2:00 P.M.—Second Session

Effects on Crystal Growth
by *Bruce Chalmers*, Harvard University

Impurities and Imperfections in Metallic Diffusion
by *David Lazarus*, University of Illinois

Role of Structural Impurities on Phase Transformations
by *David Turnbull*, General Electric Co.

Sunday, Oct. 31

9:30 A.M.—Third Session

Effects on Mechanical Properties
by *E. R. Parker*, University of California

Effects on Electrical Properties
by *J. S. Koehler*, University of Illinois

Effects on Chemical Properties
by *W. D. Robertson*, Yale University

2:00 P.M.—Fourth Session

Impurity Phenomena in Semiconductors
by *J. A. Burton*, Bell Telephone Laboratories

Effects on Dielectrics and Ionic Crystals
by *R. J. Maurer*, University of Illinois

Radiation Damage
by *Frederick Seitz*, University of Illinois

Daily Technical Sessions

All Meetings in Ballroom and Red Lacquer Room, Palmer House, Chicago

Monday, Nov. 1

9:30 A.M.—Constitution Diagrams
BALLROOM, PALMER HOUSE

The Aluminum-Vanadium Alloy System
by *O. N. Carlson*, *D. J. Kenney* and *H. A. Wilhelm*, Iowa State College

Partial Phase Diagram of the Iron-Cerium System
by *James O. Jepson* and *Pol Duwez*, California Institute of Technology

The Titanium-Cobalt System
by *F. L. Orrell, Jr.*, Dow Chemical Co. and *M. G. Fontana*, Ohio State University

The System Titanium-Aluminum-Manganese
by *R. F. Domagala* and *W. Rostoker*, Armour Research Foundation of Illinois Institute of Technology

Constitution of Ordering Alloys of the System Copper-Gold
by *F. N. Rhines*, *W. E. Bond* and *R. A. Rummel*, Carnegie Institute of Technology

2:00 P.M.—Mechanical Metallurgy
BALLROOM, PALMER HOUSE

The Effect of Prestraining Under Different Stress States on the Fracture and Flow Properties of 2S-O Aluminum
by *I. Rozalsky*, Shell Oil Co.

Deformation Mechanisms in Polycrystalline Aggregates of Magnesium
by *F. E. Hauser*, *C. D. Starr*, *L. S. Tietz* and *J. E. Dorn*, University of California

Tensile and Impact Properties of Low-Carbon Martensites
by *C. C. Busby* and *H. W. Paxton*, Carnegie Institute of Technology and *M. F. Hawkes*, U. S. Naval Ammunition Depot, Hawaii

The Tensile Characteristics of Unalloyed Zirconium at Low and Moderate Temperatures
by *J. H. Keeler*, General Electric Co.

2:00 P.M.—Processing
RED LACQUER ROOM, PALMER HOUSE

The Influence of Chemical Composition on the Machinability of Rephosphorized Openhearth Screw Steel
by *E. J. Paliwoda*, Jones & Laughlin Steel Corp.

The Influence of the Grinding Process on the Structure of Hardened Steel
by *W. E. Littmann*, Timken Roller Bearing Co. and *John Wulff*, Massachusetts Institute of Technology

The Zonal Rolling Texture of Low-Carbon Steel Cold Rolled at Various Temperatures
by *C. Nusbaum*, Case Institute of Technology and *W. Brenner, Jr.*, Cold Metal Products Co.

Tuesday, Nov. 2

9:30 A.M.—Hardenability
BALLROOM, PALMER HOUSE

An Electron Metallographic Study of the Dependence of Microstructure on Hardenability
by *S. T. Ross, R. P. Sernka* and *W. E. Jominy*, Chrysler Corp.

Calculation of Hardenability in High-Carbon Alloy Steels
by *C. F. Jatczak* and *R. W. Devine, Jr.* Timken Roller Bearing Co.

The Hardenability of Carbon Toolsteel
by *N. J. Culp*, Carpenter Steel Co.

Effect of Carbon and Nitrogen on the Attainable Hardness of Martensitic Steels
by *A. E. Nehrenberg, P. Payson* and *P. Lillys* Crucible Steel Co. of America

11:30 A.M.—Canadian Fellowship Hour and Luncheon
ROOM 18, PALMER HOUSE

2:00 P.M.—Physical Metallurgy
BALLROOM, PALMER HOUSE

Conditions for Dendritic Growth in Alloys
by *W. Morris, W. A. Tiller, J. W. Rutter* and *W. C. Winegard* University of Toronto

Stress-Corrosion Mechanism in a Magnesium-Base Alloy
by *D. K. Priest*, Pfaudler Co.
F. H. Beck and *M. G. Fontana*, Ohio State University

Thermodynamics of Binary Interstitial Solid Solutions
by *R. Speiser* and *J. W. Spretnak*, Ohio State University

Influence of Substructure on the Shape of the Creep Curve
by *T. Hazlett* and *R. D. Hansen*, University of California

Wednesday, Nov. 3

9:00 A.M.— Annual Meeting

10:30 A.M.—Campbell Memorial Lecture
BALLROOM, PALMER HOUSE

Factors Affecting Directional Properties in Aluminum Wrought Products
by *Kent R. Van Horn*, Director of Research, Aluminum Co. of America

2:00 P.M.—Mechanical Properties
BALLROOM, PALMER HOUSE

The Elastic Limit and Yield Behavior of Hardened Steels
by *H. Muir*, Otago University, Dunedin, New Zealand
B. L. Averbach and *Morris Cohen* Massachusetts Institute of Technology

Effect of Composition on Transverse Properties of Slack-Quenched Steel
by *J. Vajda* and *P. E. Busby* Carnegie Institute of Technology

The Statistical Fatigue Properties of Lamellar and Spheroidal Eutectoid Steel
by *G. E. Dieter*, Ordnance Corps
R. F. Mehl and *G. T. Horne* Carnegie Institute of Technology

Effect of Static Stress on the Damping of Some Engineering Alloys
by *A. W. Cochardt*, Westinghouse Electric Corp.

2:00 P.M.—Ferrous Physical Metallurgy
RED LACQUER ROOM, PALMER HOUSE

Further Study of Microstructural Changes on Tempering Iron-Carbon Alloys
by *B. S. Lement*, *B. L. Averbach* and *M. Cohen* Massachusetts Institute of Technology

Effects of Cold Work on Cementite in Steel
by *D. V. Wilson*, Birmingham University, England

The Isothermal Transformation of Austenite Under Externally Applied Tensile Stress
by *S. Bhattacharyya* and *G. L. Kehl*, Columbia University

Thursday, Nov. 4

9:30 A.M.—Stainless
BALLROOM, PALMER HOUSE

The Effect of Cold Work and Recrystallization on the Formation of the Sigma Phase in Highly Stable Austenitic Stainless Steels
by *A. J. Lena* and *W. E. Curry*, Allegheny Ludlum Steel Corp.

The Laves and Chi Phases in a Modified 12 Cr Stainless Alloy
by *F. L. VerSnyder* and *H. J. Beattie, Jr.* General Electric Co.

Austenitic Chromium-Manganese-Nickel Steels Containing Nitrogen
by *R. Franks, W. O. Binder* and *J. Thompson* Electro Metallurgical Co.

The Effect of Deformation on the Martensitic Transformation in Austenitic Stainless Steels
by *H. C. Fiedler*, General Electric Co.
B. L. Averbach and *M. Cohen* Massachusetts Institute of Technology

9:30 A.M.—Heat Treatment
RED LACQUER ROOM, PALMER HOUSE

The Role of Water Vapor and Ammonia in Case Hardening Atmospheres
by *P. A. Clarkin* and *M. B. Bever* Massachusetts Institute of Technology

Effect of Heat Treatment Upon Microstructures, Microconstituents, and Hardness of a Wrought Cobalt-Base Alloy
by *J. W. Weeton* and *R. A. Signorelli* Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics

Secondary Graphitization of Quenched and Tempered Ductile Cast Iron
by *J. C. Danko* and *J. F. Libsch*, Lehigh University

A Method for Determining the Continuous Cooling Transformations in Steel
by *R. D. Chapman* and *W. E. Jominy*, Chrysler Corp.

2:00 P.M.—High Temperature
RED LACQUER ROOM, PALMER HOUSE

Elevated-Temperature Properties of Ductile Cast Irons
by *C. R. Wilks, M. A. Matthews* and *R. Wayne Kraft, Jr.* American Brake Shoe Co.

Effect of Cold Work on the High-Temperature Creep Properties of Dilute Aluminum Alloys
by *R. E. Frenkel, Oleg D. Sherby* and *John E. Dorn* University of California

Creep-Tempering Relationships in Hardened 4.5% Chromium Steels

by *E. C. Roberts*, Montana School of Mines
N. J. Grant and *Morris Cohen* Massachusetts Institute of Technology

The Strength of Wrought Zirconium-Base Binary Alloys at 1800 to 2200° F.

by *H. A. Saller*, *J. T. Stacy* and *S. W. Porembka* Battelle Memorial Institute

6:30 P.M.—Cocktail Hour
FOYER, BALLROOM, PALMER HOUSE

7:30 P.M.—Annual Banquet
BALLROOM, PALMER HOUSE

10:30 P.M.—Dancing
RED LACQUER ROOM, PALMER HOUSE

Lecture Course on Temperature Measurement

ROOM 14, PALMER HOUSE

Monday, Nov. 1—4:30 P.M.

Industrial Temperature Measurement With Thermocouple Pyrometers
by *W. E. Belcher, Jr.*, Minneapolis-Honeywell Regulator Co.

Tuesday, Nov. 2—4:30 P.M.

Industrial Temperature Measurement With Total Radiation and Optical Pyrometers
by *Donald Robertson*, Leeds and Northrup Co.

Wednesday, Nov. 3—4:30 P.M.

Industrial Temperature Measurement With Resistance Thermometers and Filled Systems
by *W. F. Hickes*, Foxboro Co.

*Special Session**

Monday, Nov. 1—9:30 A.M.

Laboratory Instruction in Process Metallurgy
PALMER HOUSE

Development of Laboratory Experiments for the Unit Process Approach to Extractive Metallurgy
by *R. Schuhmann, Jr.*, Purdue University

The Role of Metallurgical and Thermodynamic Problems in the Metallurgical Engineering Laboratory
by *C. S. Samis*, University of British Columbia

Unit Process Experiments in Fluid Flow, Combustion, and Heat Transfer for Metallurgical Engineering Students
by *W. O. Philbrook*, Carnegie Institute of Technology

Special Problems for Experiments in Process Metallurgy Laboratory
by *A. W. Schlechten*, Missouri School of Mines

The Role of Electrochemical Experiments in Process Metallurgy Instruction
by *Herbert H. Kellogg*, Columbia University

*By ASM Advisory Committee on Metallurgical Education.

Industrial Heating Sessions

Presented by the Industrial Heating Equipment Association Under the auspices of the American Society for Metals

Tuesday, Nov. 2

9:30 A.M.—Atmospheres
RED LACQUER ROOM, PALMER HOUSE

Theory of Gases
by *Allen G. Hotchkiss*, General Electric Co.

Exothermic Atmosphere
by *W. H. Boyd*, Gas Atmospheres, Inc.

Endothermic Atmosphere
by *Ralph J. Perrine*, Electric Furnace Co.

Dry Nitrogen-Base Prepared Atmosphere
by *Donald Beggs*, Surface Combustion Corp.

Dissociated Ammonia
by *M. R. Ogle*, Drever Co.

Atmospheres—Their Control and Safety
by *W. L. Besselman*, Leeds & Northrup Co.

2:00 P.M.—Atmosphere Applications
INTERNATIONAL AMPHITHEATRE

Carburizing
by *Walter Holcroft*, Holcroft & Co.

The Equilibrium Relationship for Dew-Point Measurement and Control
by *N. K. Koebel*, Lindberg Engineering Co.

Practical Applications of Dew-Point Measuring and Control
by *O. E. Cullen*, Surface Combustion Corp.

Brazing
Movie by *LeRoy B. Thompson*

Carbo-Nitriding
by *Harold Ipsen*, Ipsen Industries

Neutral Heat Treating
by *A. W. Frank*, Hevi Duty Electric Co.

Sintering
by *Carl G. Paulson*, C. I. Hayes, Inc.

Wednesday, Nov. 3

2:00 P.M.—Induction Heat
INTERNATIONAL AMPHITHEATRE

Induction Melting
by *G. W. Holz*, Lindberg Engineering Co.

Induction Brazing
by *E. S. Goodridge*, Induction Heating Corp.

Induction Heat Treating
by *H. B. Osborn, Jr.*, Tocco Div., Ohio Crankshaft Co.

Sixty-Cycle Induction Heating for Forming and Extrusion
by *John A. Logan*, Magnethermic Corp.

High-Frequency Induction Heating for Hot Forging
by *Frank T. Chesnut*, Ajax Electrothermic Corp.

Dual-Frequency Heating for Hot Forging
by *Carl P. Bernhardt*, Westinghouse Electric Corp.

Institute of Metals Division

American Institute of Mining and Metallurgical Engineers

All Meetings at Morrison Hotel, Chicago

Monday, Nov. 1

9:30 A.M.—Deformation
BALLROOM, MORRISON

Mechanism of Ortho Kink-Band Formation in Compressed Zinc Monocrystals
by *J. J. Gilman*, General Electric Co.

Strain Hardening of Latent Slip Systems in Zinc Crystals
by *E. H. Edwards*, Standard Oil Co. of California, and *J. Washburn*, University of California

Effects of Temperature on the Deformation of Beta Brass
by *C. S. Barrett*, University of Chicago

Quantitative Substructure and Tensile Property Investigations of Nickel Alloys
by *E. R. Parker* and *B. Ancker* } University of California

Stress-Strain Characteristics and Slip Band Formation in Metal Crystals
by *F. C. Rosi*, RCA Laboratories

A Method of Measuring the Contribution of Crystal Structure to the Hardness of Metals
by *Walston Chubb*, Battelle Memorial Institute

9:30 A.M.—Constitution
COTILLION ROOM, MORRISON

Columbium-Vanadium Alloy System
by *H. A. Wilhelm*, *O. N. Carlson* and *J. M. Dickenson* } Iowa State College

Solid Solubility of Oxygen in Columbium
by *A. U. Seybolt*, General Electric Co.

Solubility of Oxygen in Alpha Iron
by *A. U. Seybolt*, General Electric Co.

Precipitation of Iron Oxide From Alpha-Iron-Oxide Solid Solutions
by *A. U. Seybolt*, General Electric Co.

Chromium-Rich Portion of the Chromium-Nickel Phase Diagram
by *Charles Stein* and *N. J. Grant* } Massachusetts Institute of Technology

Effect of Nitrogen on Sigma Formation in Nickel-Chromium Steels at 1200° F.
by *G. F. Tisinai*, *J. K. Stanley* and *C. H. Samans* } Standard Oil Co. of Indiana

Solubility and Decomposition Pressures of Hydrogen in Alpha Zirconium
by *E. A. Gulbransen* and *K. F. Andrew* } Westinghouse Electric Corp.

A Metallographic Study of Equilibrium Relationships in 3 S Aluminum Alloy
by *P. R. Sperry*, Kaiser Aluminum and Chemical Corp.

2:00 P.M.—Diffusion
COTILLION ROOM, MORRISON

Mobilities in Diffusion in Alpha Brass
by *G. T. Horne* and *R. F. Mehl* } Carnegie Institute of Technology

Self-Diffusivity Along Edge Dislocation Singular Lines in Silver
by *A. H. Hendrickson* and *E. S. Machlin* } Columbia University

Rate of Self-Diffusion in Polycrystalline Magnesium
by *P. G. Shewmon* and *F. N. Rhines* } Carnegie Institute of Technology

Determination of the Self-Diffusion Coefficients of Gold by Autoradiography
by *H. C. Gatos*, E. I. du Pont de Nemours and Co., Inc. and *A. D. Kurtz*, Massachusetts Institute of Technology

Cation Self-Diffusion in Wustite and Cobaltous Oxide and an Examination of the Decrease of Surface Activity Method of Measuring Self-Diffusion Coefficients
by *R. E. Carter*, Department of Mines and Technical Surveys, Canada and *F. D. Richardson*, Imperial College of Science and Technology, England

Solution Rate of Solid Aluminum in Molten Aluminum-Silicon Alloy
by *C. M. Craighead*, *E. W. Cawthorne* and *R. I. Jaffee* } Battelle Memorial Institute

2:00 P.M.—Powder Metallurgy and Oxidation
BALLROOM, MORRISON

Electron Optical Study of the Initial Stages of Oxidation of High-Purity Iron at Oxygen Pressures of 0.1 to 2 Micron of Hg Between 650° to 850° C.
by *W. A. McMillan*, *K. F. Andrew* and *E. A. Gulbransen* } Westinghouse Research Laboratories

High-Pressure Oxidation of Metals—Tantalum in Oxygen
by *R. C. Peterson*, *M. E. Wadsworth* and *W. M. Fassell, Jr.* } University of Utah

Warm Pressing of Beryllium Powder
by *N. P. Pinto*, Sylvania Electric Products, Inc.

Influence of Additives in the Production of High Coercivity of Ultra-Fine Iron Powder
by *E. W. Stewart*, E. I. duPont de Nemours & Co., Inc. *G. P. Conard II* and *J. F. Libsch* } Lehigh University

8:00 P.M.—Special Session on Metal Science
BALLROOM, MORRISON

Precipitation Out of Dual Solid Solutions of Carbon and Nitrogen in Iron
by *C. Wert*, University of Illinois

Creep of Silver Bromide at High Temperatures
by *R. W. Christy*, Dartmouth College

The Effect of Relative Crystal and Boundary Orientations on Grain Boundary Diffusion Rates
by *D. Turnbull* and *R. E. Hoffman* } General Electric Co.

Effect of the Structure of Dislocation Boundaries on Yield Strength
by *J. Washburn*, University of California

Tuesday, Nov. 2

9:00 A.M.—General
COTILLION ROOM, MORRISON

Influence of Carbon and Manganese on the Properties of Semikilled Hot Rolled Steel
by *F. W. Boulger* and *R. H. Frazier* } Battelle Memorial Institute

Temper Embrittlement of 5140 Steel
by *S. A. Bush* and *C. A. Siebert* } University of Michigan

The Coefficients of Thermal Expansion of Zirconium
by *R. B. Russell*, Massachusetts Institute of Technology

Physical and Mechanical Properties of Rhenium
by *C. T. Sims*, *C. M. Craighead* and *R. I. Jaffee* } Battelle Memorial Institute

The Ferromagnetism of Certain Manganese-Rich Alloys
by *E. R. Morgan*, Ford Motor Co.

The Preparation and Arc Melting of High Purity Iron
by *G. W. P. Rengstorff* and *H. B. Goodwin* } Battelle Memorial Institute

Mathematical Methods for Zone Melting Processes
by *Howard Reiss*, Bell Telephone Laboratories

The Viscosity and Density of Liquid Lead-Tin and Antimony-Cadmium Systems
by *H. J. Fisher*, Department of Mines and Technical Surveys, Canada and *Arthur Phillips*, Yale University

9:00 A.M.—Third Annual Symposium on Titanium
BALLROOM, MORRISON

Interesting Alloy Systems, Commercial Alloys, Melting and Hot Working of Titanium
by *D. J. McPherson*, Armour Research Foundation of Illinois Institute of Technology

General Physical Metallurgy, Including Effects of Interstitials, Heat Treatment and Joining of Titanium
by *R. I. Jaffee*, Battelle Memorial Institute

Hydrogen in Titanium
by *Harold Kessler*, Titanium Metals Corp. of America

Use of Titanium in Airframes
by *Gordon Fairbairn*, North American Aviation, Inc.

Use of Titanium in Aircraft of the Future
by *N. E. Promisel*, Navy Department, Bureau of Aeronautics

2:00 P.M.—Third Annual Symposium on Titanium
BALLROOM, MORRISON

Panel Discussion Conducted by:
L. A. Best, Douglas Aircraft Co.
L. R. Frazier, General Electric Co.
T. W. Lippert, Titanium Metals Corp. of America
Frank Vandenburgh, Mallory-Sharon Titanium Corp.
Major R. J. Kotfila, Wright-Patterson Air Force Base
J. B. Sutton, E. I. du Pont de Nemours & Co., Inc.

2:00 P.M.—Phase Transformations and Recrystallization
COTILLION ROOM, MORRISON

On the Nucleation of Pearlite
by *M. E. Nicholson*, University of Chicago

A Study of the Effect of Boron on the Decomposition of Austenite
by *C. R. Simcoe*, *A. R. Elsea* and *G. K. Manning* } Battelle Memorial Institute

Characteristics and Stabilization of the Bainite Reaction
by *R. F. Hehemann* and *A. R. Troiano* } Case Institute of Technology

Some Characteristics of the Isothermal Martensitic Transformation
by *B. L. Averbach*, *C. H. Shih* and *Morris Cohen* } Massachusetts Institute of Technology

Ordering Reaction of the Cu_3Pd Alloy
by *A. H. Geisler* and *J. B. Newkirk* } General Electric Co.

A Mechanism for the Origin of Recrystallization Nuclei
by *J. P. Nielsen*, New York University

A New High-Temperature Reaction Calorimeter
by *O. J. Kleppa*, University of Chicago

Wednesday, Nov. 3

2:00 P.M.—Creep
COTILLION ROOM, MORRISON

Some Observations on Grain Boundary Shearing During Creep
by *J. E. Dorn*, *Bernard Fazen* and *O. D. Sherby* } University of California

Some Observations on the Tertiary Stage of Creep of High Purity Aluminum
by *G. R. Wilms*, Reference Standards Laboratories, Australia

Creep-Rupture Characteristics of Aluminum-Magnesium Solid Solution Alloys
by *A. W. Mullendore*, Wright-Patterson Air Force Base and *N. J. Grant*, Massachusetts Institute of Technology

Creep Behavior of Magnesium-Cerium Alloys
by *C. S. Roberts*, Dow Chemical Co.

Creep-Rupture Properties and Structural Changes in Carbon and Low Alloy Steels
by *A. B. Wilder*, *E. F. Ketterer* and *D. B. Collyer* } National Tube Division, U. S. Steel Corp.

Institute of Metals Div.—Cont.

Wednesday, Nov. 3

2:00 P.M.—Titanium
BALLROOM, MORRISON

Correlation Between Microstructure and Resistivity of Transforming Ti-Mn Alloys

by *D. J. Delazaro*, Kropp Forge Co., and *D. W. Levinson*, Armour Research Foundation

Effect of Alpha Solutes on the Heat Treatment Response of Ti-Mn Alloys

by *H. R. Ogden*, *F. C. Holden* and *R. I. Jaffee*, Battelle Memorial Institute

Mechanical Properties of Alpha Titanium as Affected by Structure and Composition

by *R. I. Jaffee*, *F. C. Holden* and *H. R. Ogden*, Battelle Memorial Institute

Heat Treatment and Mechanical Properties of Ti-Cu Alloys

by *F. C. Holden*, *A. A. Watts*, *H. R. Ogden* and *R. I. Jaffee*, Battelle Memorial Institute

Structure and Properties of Ti-C Alloys

by *H. R. Ogden*, *R. I. Jaffee* and *F. C. Holden*, Battelle Memorial Institute

The Titanium-Lead System

by *Paul Farrar* and *Harold Margolin*, New York University

Phase Transformations in Titanium-Rich Alloys of Iron and Titanium

by *J. G. Parr* and *D. H. Polonis*, University of British Columbia

Selected Isothermal Sections in the Titanium-Rich Corners of the Systems Ti-Fe-O, Ti-Cr-O and Ti-Ni-O

by *W. Rostoker*, Armour Research Foundation of Illinois Institute of Technology

Society for Nondestructive Testing

All Meetings in Morrison Hotel, Chicago

Monday, Nov. 1

9:00 A.M.—Educational Program

Orientation Lecture

by *R. C. McMaster*, Battelle Memorial Institute

Sources of Defects Located by Nondestructive Testing

by *C. E. Betz*, Magnaflux Corp.

Radiography by *R. G. Tobey*, Eastman Kodak Co.

Magnetic Particle Inspection

by *W. E. Thomas*, Magnaflux Corp.

1:30 P.M.—Educational Program

Penetrant Inspection by *H. Migel*, Magnaflux Corp.

Ultrasonics—Reflection, Resonance and Immersion Testing

by *J. C. Smack*, Sperry Products Inc., *Peter Bloch*, Branson Instruments, Inc. *J. E. Rutledge*, McConnell Aircraft Co.

Evaluation of Indications of Discontinuities

by *J. H. Bly*, X-Ray, Inc.

Tuesday, Nov. 2

9:00 A.M.—Radiography

High Sensitivity Fluoroscopy

by *Charles A. Mitchell*, Mitchell Radiation Products Corp.

2-Mev. Constant Potential Radiography of Steel

by *Stanley S. Stacey*, Foster Wheeler Corp.

The Polaroid Process for Industrial Radiography

by *J. W. Dutli* and *J. F. Torbert*, Los Alamos Scientific Laboratory

Technical Writing and Presentations

by *W. A. Koehnline* and *Clyde R. Tipton, Jr.*, Battelle Memorial Institute

2:00 P.M.—Nondestructive Testing Abroad

The Preparation and Handling of Intense Radioactive Sources

by *Peter J. Stewart*, Isotope Products Ltd., Canada

New Techniques in Electromagnetic Nondestructive Testing Methods

by *Friedrick Foerster*, Institut Dr. Foerster, Germany

The German Society for Nondestructive Testing and a Review of Nondestructive Testing in Germany

by *R. Seifert*, Hamburg, Germany

Wednesday, Nov. 3

9:00 A.M.—Ultrasonics

Reference Standards by *Al Barath*, Douglas Aircraft Co.

Subject to Be Announced

by *J. B. Morgan*, Aluminum Co. of America

The Sound of Quality Control

by *J. E. Rutledge*, McDonnell Aircraft Co.

2:00 P.M.—Presentation of Awards

Mehl Honor Lecture by *E. E. Charlton*, General Electric Co.

Thursday, Nov. 4

9:00 A.M.—Nondestructive Testing as Applied to Airline, Railway, Oil and Shipbuilding

Panel Discussion and Papers by

A. S. Pedrick, Southern Pacific Railroad
George G. Thurston, Consulting Metallurgist
Robert E. Reynolds, Lockheed Aircraft Co.
Ray McBrian, Denver & Rio Grande Western Railroad Co.
A. W. Gilbert, Carbide & Chemical Co.
A. K. Hutton, Newport News Shipbuilding and Drydock Co.

American Welding Society

All Meetings at Sherman Hotel, Chicago

Monday, Nov. 1

10:00 A.M.—Prize Awards and Adams Lecture
LOUIS XVI ROOM, SHERMAN

The Toughness of Weldability
by *William L. Warner*, Watertown Arsenal

2:00 P.M.—Resistance Welding
BALLROOM, SHERMAN

Flash Welding High-Strength Steels
by *W. G. Fassnacht*, Bendix Aviation Corp.

Effect of Post Treatment on the Properties of Flash Welds
by *Ernest F. Nippes*, *Warren F. Savage*, *Gordon Grotke* and *S. M. Robelotto*, Rensselaer Polytechnic Institute

The Effects of Prestressing on the Strength Characteristics of Spot Welds in 17-7 Stainless Steels Under Cyclic Loads
by *V. N. Krivobok*, International Nickel Co.
J. A. Choquet and *G. Welter*, Ecole Polytechnique

2:00 P.M.—Weldability
ASSEMBLY ROOM, SHERMAN

The Effect of Microstructure on Notch Toughness—Part II
by *John H. Gross* and *Robert D. Stout*, Lehigh University

Impact Testing Weld Metal and Heat-Affected Zone Simultaneously
by *W. P. Hatch, Jr.* and *C. E. Hartbower*, Watertown Arsenal

Applicability of Charpy Test Data
by *Peter P. Puzak*, *Martin E. Schuster* and *W. S. Pellini*, Naval Research Laboratory

6:00 P.M.—President's Reception
CRYSTAL AND LOUIS XVI ROOMS, SHERMAN

8:00 P.M.—National Dinner
BAL TABARIN, SHERMAN

Tuesday, Nov. 2

9:30 A.M.—Weldability
ASSEMBLY ROOM, SHERMAN

Isothermal Studies on Weld-Metal Microcracking in Mild Steel
by *Alan E. Flanigan* and *Z. P. Saperstein*, University of California

Crack-Starter Tests of Ship Fracture and Project Steels
by *P. P. Puzak*, *Martin E. Schuster* and *W. S. Pellini*, Naval Research Laboratory

Continuous Cooling Transformation Characteristics of Three Types of Weld Metal
by *E. F. Nippes* and *E. C. Nelson*, Rensselaer Polytechnic Institute

9:30 A.M.—Resistance Welding
CRYSTAL ROOM, SHERMAN

Spot Welding Aluminum With Single-Phase Equipment
by *J. W. Kehoe* and *D. R. McCutcheon*, Westinghouse Electric Corp.

Seam Welding Low-Carbon Steel
by *M. L. Begeman* and *Gene C. Walker*, University of Texas

Automatic Percussion Welding
by *A. L. Quinlan*, Western Electric Co.

9:30 A.M.—Shielded-Arc Welding
LOUIS XVI ROOM, SHERMAN

Recent Developments in Contact Electrodes
by *D. L. Mathias*, Arcrods Corp.

Electrodes With Powdered Metal Coatings, A Progress Report
by *Jerry Hinkel*, Lincoln Electric Co.

Metallic Rectifiers for Arc Welders
by *G. K. Willecke*, Miller Electric Mfg. Co.

2:00 P.M.—Section Officers Meeting
CRYSTAL ROOM, SHERMAN

2:00 P.M.—Weldability
ASSEMBLY ROOM, SHERMAN

Arc Welding Embrittlement of Powder Metals
by *Albert Sill, Jr.* and *C. C. Mathias*, Sperry Corp.

Weldability of Wrought, High-Alloy Materials
by *R. P. Culbertson*, Haynes Stellite Co.

2:00 P.M.—Surfacing
LOUIS XVI ROOM, SHERMAN

High-Nickel Alloy Overlays on Ferrous Metals
by *George R. Pease*, *H. B. Bott* and *H. C. Waugh*, International Nickel Co.

The Inert-Gas Metal-Arc Overlay Process
by *C. R. Felmley*, Air Reduction Sales Co., Inc.

Automatic Hard Surfacing in the Mining and Construction Industries
by *I. R. Bartter*, Automatic Welding Co.

Wednesday, Nov. 3

9:30 A.M.—Inert-Arc Welding
ASSEMBLY ROOM, SHERMAN

New Techniques in Inert-Gas-Shielded Metal-Arc Welding
by *R. W. Tuthill*, General Electric Co.

Inert-Gas Welding of Stator Packs
by *F. J. Pilia*, Linde Air Products Co.

A Production Application of Inert-Gas-Shielded Metal-Arc Welding of Mild Steel
by *John L. Lang*, Lukenweld Div., Lukens Steel Co.

Wednesday, Nov. 3 (Cont.)

9:30 A.M.—Aircraft and Rocketry
CRYSTAL ROOM, SHERMAN

Production of High-Strength Aluminum Alloy Rocket Motor Tubing by Means of an Induction Weld Tube Mill
by *W. S. Tenner* and *H. C. Wheeler*, U. S. Naval Ordnance Test Station

Metallurgical Aspect of Welding Precipitation Hardening Stainless Steels
by *C. W. Funk* and *M. J. Granger*, Aerojet-General Corp.

The Macro-Etch System of Evaluating Quality of Resistance Welding
by *D. O. Samuelson* and *F. G. Harkins*, Solar Aircraft Co.

9:30 A.M.—Titanium, Zirconium and Molybdenum
LOUIS XVI ROOM, SHERMAN

Notch Toughness of Weld Deposits in Titanium Plate
by *D. M. Daley, Jr.* and *C. H. Harthower*, Watertown Arsenal

The Welding of Zirconium
by *Ralph V. Hilkert* and *Harold H. Hollenbeck*, Titanium Alloy Mfg. Div., Nat'l Lead Co.

The Influence of Oxygen on the Joining of Molybdenum
by *Timothy G. Perry*, *H. Stephen Spacil* and *John Wulff*, Massachusetts Institute of Technology

2:00 P.M.—Symposium on Fused Metallized Coatings*
LOUIS XVI ROOM, SHERMAN

Fundamentals of Fused Metallized Coatings
by *Bela Ronay*, U. S. Naval Engineering Experimental Station

Practical Applications of Fused Self-Fluxing Metallized Coatings
by *Harvey S. Miller*, New England Hardfacing Co.

Practical Applications of Fused Non-Self-Fluxing Metallized Coatings
by *Sam Tour*, Sam Tour & Co., Inc.

2:00 P.M.—Pressure Vessels and Piping
ASSEMBLY ROOM, SHERMAN

The Plastic Fatigue Behavior of High-Strength Pressure Vessel Steels
by *John H. Gross* and *Robert D. Stout*, Lehigh University

Further Studies of the Biaxial Fatigue Properties of Pressure Vessel Steels
by *C. E. Bowman* and *T. J. Dolan*, University of Illinois

Automatic Tungsten Inert-Arc Welding of Pipes in Position, Without the Use of Backing Rings
by *L. C. McNatt*, Benjamin F. Shaw Co.

2:00 P.M.—Brazing
CRYSTAL ROOM, SHERMAN

Silver Brazing of Refractory Metals
by *C. H. Chatfield*, Handy & Harman

*Sponsored by AWS Committee on Metallizing

Filler-Metal Strengths in Brazed Copper Joints
by *W. H. Munse* and *D. C. Crawford*, University of Illinois

Investigation of the Factors Determining the Tensile Strength of the Brazed Joint
by *Nikolajs Bredzs*, Armour Research Foundation of Illinois Institute of Technology

6:30 P.M.—WRC University Dinner
EMERALD ROOM, SHERMAN

8:00 P.M.—WRC University Conference
CRYSTAL ROOM, SHERMAN

Thursday, Nov. 4

9:30 A.M.—Aircraft
CRYSTAL ROOM, SHERMAN

Considerations for Fatigue in Aircraft Welding Design
by *J. Koziarski*, Piasecki Helicopter Corp.

Properties of Welds in Al-Mg-Mo Alloys XK186 and XK183
by *D. A. Cook* and *S. L. Channon*, Kaiser Aluminum and Chemical Corp., and *A. R. Hard*, State College of Washington

High-Temperature Alloy Brazing of Thin Materials for Jet Engines
by *A. S. Rose* and *W. N. Lewis*, I-T-E Circuit Breaker Co.

9:30 A.M.—Design and Production
ASSEMBLY ROOM, SHERMAN

Prediction of Angular Distortion Caused by One-Pass Fillet Welding
by *T. Kumose*, *T. Yoshida*, *T. Abbe* and *H. Onoue*, Yokohama Shipyard & Engine Works, Mitsubishi Nippon Heavy-Industries, Ltd.

Triaxial Tensile Stresses in Arc Welded Mild Steel
by *Harry E. Kennedy*, University of California

Automatic Welding Builds Railroad Cars
by *H. D. Hollis*, Texas & Pacific Railway Co.

9:30 A.M.—Cutting
BALLROOM, SHERMAN

Oxygen Cutting With Iron Powder and Chemical Flux Additives
by *R. L. Deily* and *J. R. Kirwin*, Air Reduction Sales Co.

Sigma Arc Cutting
by *R. S. Babcock*, Linde Air Products Co.

Improved Method of Oxy-Fuel Gas Combustion
by *Edward H. Roper*, Air Reduction Sales Co.

10:00 A.M.—Board of Directors Meeting
JADE ROOM, SHERMAN

2:00 P.M.—Business Meeting
CRYSTAL ROOM, SHERMAN

American Welding Society

Friday, Nov. 5

9:30 A.M.—Applications
OLD CHICAGO ROOM, SHERMAN

How to Apply Semi-Automatic Submerged-Arc Welding
by *Robert A. Wilson*, Lincoln Electric Co.

Mechanized Flame Descaling, Dehydrating and Priming of Prefabricated Plate
by *C. H. Cowan*, Avondale Marine Ways, Inc., and *J. R. Kirwin*, Air Reduction Sales Co.

Automatic Hard Facing With Mild Steel Electrodes and Agglomerated Alloy Fluxes
by *J. S. McKeighan*, Lincoln Electric Co.

9:30 A.M.—Structural
BALLROOM, SHERMAN

Behavior of Welded Single-Span Frames Under Combined Loading
by *C. G. Schilling*, *F. W. Schutz, Jr.*, and *L. S. Beedle*, Lehigh University

Fatigue Strength of Butt Welds in Structural Steels
by *L. A. Harris*, *G. E. Nordmark* and *N. H. Newmark*, University of Illinois

New Concepts in Spot X-Ray of Welded Structures
by *Harold Hovland*, Industrial X-Ray Engineers

9:30 A.M.—High-Temperature Materials
ASSEMBLY ROOM, SHERMAN

An Investigation of the Hot Ductility of High-Temperature Alloys
by *Ernest F. Nippes*, *Warren F. Savage*, *H. F. Mason* and *B. J. Bastian*, Rensselaer Polytechnic Institute

Interpreting Graphitization in High-Temperature, High-Pressure Steam Piping
by *H. Thielsch*, *E. M. Phillips* and *E. R. Jerome, Jr.*, Grinnell Co., Inc

The Welding of Type 347 Stainless Steel for the Higher Steam Turbine Operating Temperatures
by *R. M. Curran* and *A. W. Rankin*, General Electric Co

Metals Division, Special Libraries Association

Wednesday, Nov. 3

9:30 A.M.—Field Trip to John Crerar Library

Thursday, Nov. 4

9:30 A.M.—The Small Metallurgical Library
CONRAD HILTON HOTEL

How to Start a Small Metallurgical Library
by *Marjorie O. Baker*, Baker & Co., Inc.

The Paradoxical Trade Catalog
by *William S. Budington*, John Crerar Library

Handling Patents in a Small Technical Library
by *Lois W. Brock*, General Tire & Rubber Co.

2:00 P.M.—Economics and Marketing in the Metallurgical Field
CONRAD HILTON HOTEL

The Importance of Libraries in Market Research
by *Don E. Stewart*, United States Steel Corp.

Sources of Information on the Nonferrous Metals
by *Irving Lipkowitz*, Reynolds Metals Co

Friday, Nov. 5

9:00 A.M.—Field Trip to Inland Steel Co.

Research in the Steel Industry
by *James W. Halley*, Inland Steel Co.

What to See at the Metal Show

Exhibitors
Booth Numbers
and Descriptions
of Products
in Ten Subject
Categories

Producers of Metals and Alloys

EVERY summer the editors of *Metal Progress* solicit information from the exhibitors at the National Metal Exposition. We place especial emphasis in the questionnaire on what new things will be shown to visitors. We confidently expect the replies to fall into a pattern, a pattern of progress. What is the pattern of progress in the *production* of metals and alloys? Wherever else it may be, the data at hand indicate it in some field other than iron and steel.

As always, information from producers of metals and alloys is not too bulky because such firms are few, in comparison with the number of fabricators or manufacturers of fabricating equipment and supplies. This would be true even if there were no trend toward fewer and larger corporations. Further, the firms which exhibit are those which have expanded operations, activities and products to meet the new demands of today and to anticipate the needs of tomorrow.

The light metals, magnesium and aluminum, are expanding at an astonishing rate, even at a time when steel production is so low it is barely earning its overhead. For example, Dow Chemical Co. will show the wide, thin sheet now made in its new

Titanium Alloy Ingots Produced by Mallory-Sharon Titanium Corp.

magnesium rolling mill at Madison (Aug. '54, p. 104)*. Tin producers are stepping up informational activities about new and valuable uses of this ancient metal. So is the copper and brass industry through its Research Association; major producers are also supplementing their traditional products and their "Engineered Brass Alloys" (Aug. '54, p. 106) with other corrosion resistant alloys used in quantity by their principal customers. Three major interests in nonferrous metals – Union Carbide and Carbon Corp., International Nickel Co., Inc. and National Lead Co. – have, through a generation of thorough-going research, expanded each into many lines of metallurgical activity, more or less closely related to their original interests. Titanium manufacturers will be at the Chicago National Metal Exposition, looking for customers to build up a business in the arts of peace, so necessary for their future prosperity.

Representing the steel industry we see only three firms – Copperweld Steel Co., Babcock & Wilcox Co., and Allegheny Ludlum Steel Corp. – all manufacturers of specialties. The latter especially should be proud of a notable metallurgical advance, the extrusion of irregular shapes in stiff stainless steels (see p. 91). All three firms exist through their ability to produce special steels and alloys to meet specially severe service or unusual surroundings.

Take the matter of machinability: Joseph T. Ryerson & Son, Inc. wants to be known as the "Home of Free Machining Steels", and will feature not only the older "Ledloy" (leaded carbon steel) but also a new chromium-molybdenum steel with 0.25% lead, which they say will cut at 50% higher speed and still give double the tool life (Aug. '53, p. 143). Nearby will be Scovill Mfg. Co., America's oldest firm in the brass business, showing a section of a warehouse stocking "high speed brass rod" which machines like magic – and they're going to emphasize that last word with professional magicians! Dow Chemical Co. will show magnesium alloy extrusions which machine so fast that seldom has any tool caught up with the possibilities.

What with the cost of machine tools, their operation, the machinist's wages and the overhead, do you suppose the total cost of a screw-machine part will be affected much by the raw material, whether it costs 10c (steel), 40c (brass), or 60c per lb. (magnesium) – or as the magnesium boys will quickly point out, 3c per cu.in. for steel and 4c per cu.in. for magnesium? That is to say, the metal that machines the easiest and fastest, thus cutting the labor and fixed costs the most, and still is good enough for the intended service – *that* is the metal which will be chosen for machined parts.

Take the matter of rusting, a thing endured since iron's history began, and only postponed by coating with tin or zinc or paint. More effective are the heavy electroplates, as demonstrated by American Nickeloid Co. However, none of these served when the temperatures got hot until the remarkable action of chromium in iron was discovered. If the stainless steels are not good enough, International Nickel Co., Inc. or Driver-Harris Co. will be glad to demonstrate the possibilities of various high-nickel alloys, and Haynes Stellite Co. their favorites based on cobalt. Even beyond that, into the temperatures of 1500 to 1800° F. existing in jet engines, come Kennametal, Inc.'s and Firth Sterling, Inc.'s "cermets", composite materials made of titanium and

*References are to recent articles in *Metal Progress*, where the inquiring reader will find much information.

chromium carbides and cemented with nickel-cobalt-chromium alloy, having superior high-temperature stability, creep strength and resistance to thermal shock.

In the field of metals especially resistant to chemicals and other liquids, in addition to the old-reliable copper, will be new tin alloys and alloyed electroplates exhibited by Malayan Tin Bureau and Tin Research Institute, Inc., platinum-clad sheets and tubing by Baker & Co., Inc., and the really "new" metal zirconium, now being promoted by Firth Sterling, Inc. for linings in chemical equipment and for hospital operating room equipment.

In special metals and alloys for electrical and electronic equipment, the metallurgist is as helpful as he was over 50 years ago when he rescued the incandescent lamp industry by substituting tungsten for the short-lived carbon filament. Zirconium has especial attributes fitting it to electronic devices. The firm of Handy & Harman has a silver, hardened with magnesium and nickel, which has particular interest as electrical contactors. Baker & Co., Inc., is exhibiting rhodium, one of the platinum group of metals – rare, but fortunately hard and potent in minutest layers. A hundredth of a thousandth on silver or nickel will be completely stable in industrial, hot and humid atmospheres, and consequently it lends itself to ultra-high frequency equipment, safety alarm contactors which must function unerringly, or sliding contacts of *uniform* conductivity.

Other really new metals will be there – new in the sense that they are now available in quite pure state and in large quantity. Electro Metallurgical Co. (unit of Union Carbide & Carbon Corp.) will show you metallic manganese and metallic chromium, made at the new plant at Marietta (July '53, p. 87), and describe the present and potential uses. Titanium must not be forgotten, even though the Air Forces are taking nearly all of the rapidly expanding production. Titanium Metals Corp. of America, Mallory-Sharon Titanium Corp., and Titanium Alloy Mfg. Div. of National Lead Co., will be the three exhibitors from several others which intend to see to it that peacetime industry gets enough information about their favorite metal and puts it to use.

E.E.T.

Classified List of Exhibitors and Booth Numbers

Steels (Plain and Alloy)

American Cast Iron Pipe Co.—**1020**
Allegheny Ludlum Steel Corp.—**336**
Avon Tube Div., Higbie Mfg. Co.—**1939**
Babcock & Wilcox Co.—**236**
Cold Metal Products Co.—**141**
Copperweld Steel Co., Steel Div.—**744**
Exomet, Inc.—**1539**
Firth Sterling Inc.—**315**
International Nickel Co., Inc.—**745**
Korhumel Steel & Aluminum Co.—**1624**
National Radiator Co., Plastic Metals Div.—**1911**
Ohio Steel Foundry Co.—**1435**
Precision Steel Warehouse, Inc.—**1342**
Ryerson & Son, Inc., Joseph T.—**730**
Starrett Co., L. S.—**2101**
Steel Sales Corp.—**725**
Uddeholm Co. of America, Inc.—**201**

High-Temperature Alloys

Allegheny Ludlum Steel Corp.—**336**
Alloy Engineering & Casting Co.—**1101**
American Brake Shoe Co. Electro Alloys Div.—**762**
American Cast Iron Pipe Co.—**1020**
Black Drill Co.—**1511**
Driver Co., Wilbur B.—**2029**
Driver-Harris Co.—**2267**
Exomet, Inc.—**1539**
Firth Sterling Inc.—**315**
General Alloys Co.—**652**
Haynes Stellite Co.—**653**
International Nickel Co., Inc.—**745**
Janney Cylinder Co.—**1767**
Kennametal, Inc.—**326**
Michiana Products Corp.—**1759**
Misco Fabricators, Inc.—**1730**
Ohio Steel Foundry Co.—**1435**
Steel Sales Corp.—**725**

Stainless and Corrosion Resistant Steels

Allegheny Ludlum Steel Corp.—**336**
Aloy Engineering & Casting Co.—**1101**
American Cast Iron Pipe Co.—**1020**
Cold Metal Products Co.—**141**
Driver Co., Wilbur B.—**2029**
Exomet, Inc.—**1539**
Firth Sterling Inc.—**315**
International Nickel Co., Inc.—**745**
Janney Cylinder Co.—**1767**
Ohio Steel Foundry Co.—**1435**
Ryerson & Son, Inc., Joseph T.—**730**
Steel Sales Corp.—**725**
Uddeholm Co. of America, Inc.—**201**
Uniworld Research Corp. of Am.—**126**

Copper, Nickel and Other Nonferrous Metals and Alloys

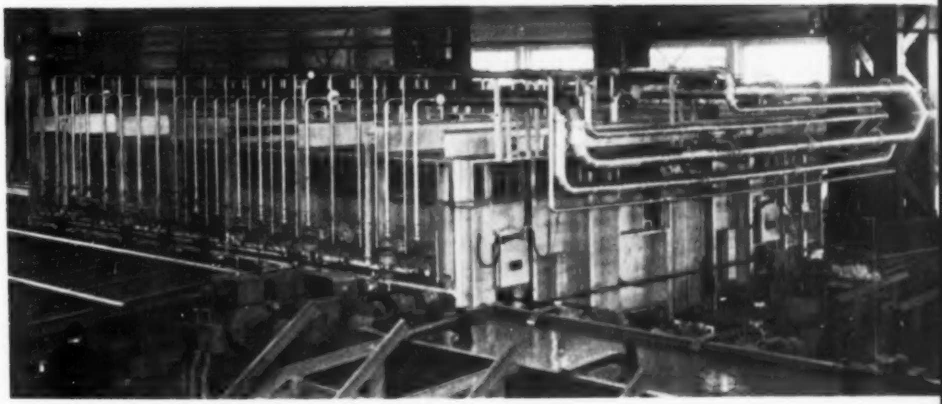
Allegheny Ludlum Steel Corp.—**336**
Alpha Metals, Inc.—**2344**
American Nickeloid Co.—**2314**
Baker & Co., Inc.—**1327**
Bridgeport Brass Co.—**1015**
Carboloy Dept., General Electric Co.—**1540**
Chase Brass & Copper Co.—**302**
Driver Co., Wilbur B.—**2029**
Driver-Harris Co.—**2267**
Electro Metallurgical Co.—**653**
Exomet, Inc.—**1539**
Fansteel Metallurgical Corp.—**1559**
H & H Tube & Mfg. Co.—**1502**
Handy & Harman—**342**
International Nickel Co., Inc.—**745**
Janney Cylinder Co.—**1767**
Malayan Tin Bureau—**1909**
National Lead Co.—**260**
Olin Industries, Inc.—**110**
Scovill Mfg. Co.—**430**
Steel Sales Corp.—**725**
Tin Research Institute, Inc.—**1901**
WW Alloys Inc. division of Fansteel Metallurgical Corp.—**1559**

Light Metals and Alloys

Allegheny Ludlum Steel Corp.—**336**
Beryllium Corp.—**1717**
Brush Beryllium Co.—**2348**
Dow Chemical Co.—**620**
Driver Co., Wilbur B.—**2029**
Exomet, Inc.—**1539**
Hills-McCanna Co.—**2301**
Korhumel Steel & Aluminum Co.—**1624**
Mallory-Sharon Titanium Corp.—**1537**
Olin Industries, Inc.—**110**
Scovill Mfg. Co.—**430**
Steel Sales Corp.—**725**
Titanium Alloy Mfg. Div., National Lead Co.—**260**
Titanium Metals Corp. of America—**226**

Ferro-Alloys

American Cast Iron Pipe Co.—**1020**
Climax Molybdenum Co.—**148**
Driver Co., Wilbur B.—**2029**
Electro Metallurgical Co.—**653**
Steel Sales Corp.—**725**
Titanium Alloy Mfg. Div., National Lead Co.—**260**
Vanadium Corp. of America—**320**



Continental's Automatic Tube Normalizing Furnace

Casting, Forging, and Refining Equipment

Much attention has been given in the technical press during the past year to three trends in metal manufacturing – namely, vacuum melting, continuous casting and the manufacture of oversized forgings.

Vacuum melting is not a new thing, but only very recently has it appeared to be a commercial operation on high-temperature alloys and even on constructional alloy steels. For such work it is essential that the operation be as nearly continuous as possible, else the vacuum is frequently broken and a ruinously large fraction of the day is spent in pumping out the equipment. An operating furnace of this sort has been designed by National Research Corp. (Sept. '53, p. 162) – whose subsidiary, Vacuum Metals Corp., has recently joined with Crucible Steel Co. of America. Also, a 1000-lb. vacuum furnace for melting and centrifugally casting high-temperature alloys used in turbine blades and disks of jet engines will receive top billing at the exhibit of F. J. Stokes Machine Co.

One user of this type of furnace estimates stress-rupture life of turbine blades is increased 2½ times over conventional arc-melted alloys. When clean metals and alloys are melted under vacuum or under a low pressure of reducing gas such as hydrogen, the resulting ingots are unusually clean, free of inclusions and therefore have high fatigue limits; furthermore, they may be made very low in oxygen, hydrogen and nitrogen. The "new" highly reactive metals like titanium are especially prone to damage from such dissolved gases.

Continuous casting has been perfected by the copper industry. Scovill Mfg. Co. has built a big new sheet mill for brass coils (Jan. '50, p. 51) depending on this process. Steel casting is not so easy; nevertheless, Babcock & Wilcox Co. has so made thousands of tons of billets for seamless tubes (March '53, p. 87). The idea is to get uniform metal, end to end, and as little axial weakness as possible. "Controlled directional solidification" is today's term for the process.

Other methods are available for ingots cast in ordinary molds: A copper stool starts solidification rapidly at the bottom; a short, squat ingot minimizes differences in composition, end to end; the

top can be kept liquid so as to feed the pipe by hot refractory collars. An electric arc or an oxyacetylene flame can furnish supplementary heat. Or a handful of exothermic powder will do the trick. Exomet, Inc., will display its "Exomold" for a similar purpose. It is a mixture of exothermic powders and clay which, when mulled with a little water, can be molded and baked into a permanent shape. The powder is ignited by the hot metal and generates the necessary heat – but the mold does not melt, the clay holds its shape.

Exomet, Inc., says that these moldable mixtures (there is one for steel, another for copper alloys, a third for aluminum of appropriate ignition temperatures) help wonderfully in the form of riser sleeves, knock-off cores, and pads when placed in molds at proper places to keep metal hot and liquid – even increase its temperature as necessary, the opposite of a chill. Alloy Engineering & Casting Co., on the other hand, will have a good story to tell any visitor about the revolutionary foundry methods it has utilized for making thin-walled castings of highest integrity (July '49, p. 51). They include ceramic molds of variable heat conductivity, baked by radio frequency electric currents, of smooth surface and high precision. Molds are stacked, cast while spinning, the metal and mold of such temperature that it solidifies just about as soon as it reaches its intended position.

Until the ordinary foundryman can handle such methods, Metallizing Co. of America will help him seal castings with slight porosity ("leakers") using one of its several packaged plants called "Mogullizers". Castings are cleaned, placed in a vacuum tank, pumped out for 20 min., a colloidal suspension at 180° F. run in, and pressure brought up to 100 psi. for 20 min., after which the castings are washed and are then pressure tight up to 10,000 psi., according to the company's pamphlets.

Of course, there are some new aspects of old familiar materials. For example, National Carbon Co. (unit of Union Carbide & Carbon Corp.) will emphasize what a useful thing carbon is with miniature equipment such as an electric furnace and cupola. Vanadium Corp. of America will show some ferro-alloys with compositions newly adjusted for the most exacting product. Electro Metallurgical Co. will also have its "Simplex ferrochrome", oysterlike pellets practically carbon-free, made by the extraordinarily interesting process described in *Metal Progress* for July '53, p. 87.

Continental Industrial Engineers, Inc., is also proud of a set of four heating and heat treating furnaces installed in a new tube mill in the Midwest. All are designed to be completely automatic. A tube is carried into the furnace along one wall by a set of water-cooled rolls; it is then rolled gradually across an inclined hearth (either by fingers, pushers, walking beams or cross conveyers – each furnace has its own design) and then out over a second train of rolls along the other wall. Tubing can vary from 2½ to 10 in. diameter and be up to 48 ft. long. Capacity is 75 tons per hr. Burner equipment is in duplicate for either gas or oil; pressure is positive to prevent air infiltration. The normalizer, shown in the photograph on p. 89, has a drop-nose section of the suspended roof on the far side over which the burners fire. On the rear (exit) side a second series of burners is arranged – all under six-zone control. E.E.T.

Classified List of Exhibitors and Booth Numbers

Melting Furnaces

Ajax Electrothermic Corp.—**752**
Ajax Engineering Corp.—**752**
American Gas Association—**854 A to F, 843 G to K**
American Gas Furnace Co.—**843-H**
Continental Industrial Engineers, Inc.—**843-G**
General Electric Co.—**1060**
Hauck Mfg. Co.—**2124**
Hones, Inc., Charles A.—**854-E**
National Carbon Co.—**653**
National Research Corp.—**1160**
Shenango-Penn Mold Co.—**2112**
Stokes Machine Co., F. J.—**2167**

Mill Equipment

Allis-Chalmers Mfg. Co.—**242**
Alloy Metal Wire Co., Div. of H. K. Porter Co., Inc.—**1645**
American Wheelabrator & Equipment Corp.—**632**
Cold Metal Products Co.—**141**
De Sanno & Son, Inc., A. P.—**2139**
Salem-Brosius, Inc.—**241**
Stanat Mfg. Co.—**1659**
Wallace Supplies Mfg. Co.—**310**

Forging Equipment

American Gas Association—**854 A to F, 843 G to K**
American Wheelabrator & Equipment Corp.—**632**
Continental Industrial Engineers, Inc.—**843-G**
Hydraulic Press Mfg. Co.—**109**
Salem-Brosius, Inc.—**241**
Surface Combustion Corp.—**714**

Foundry Equipment and Processes

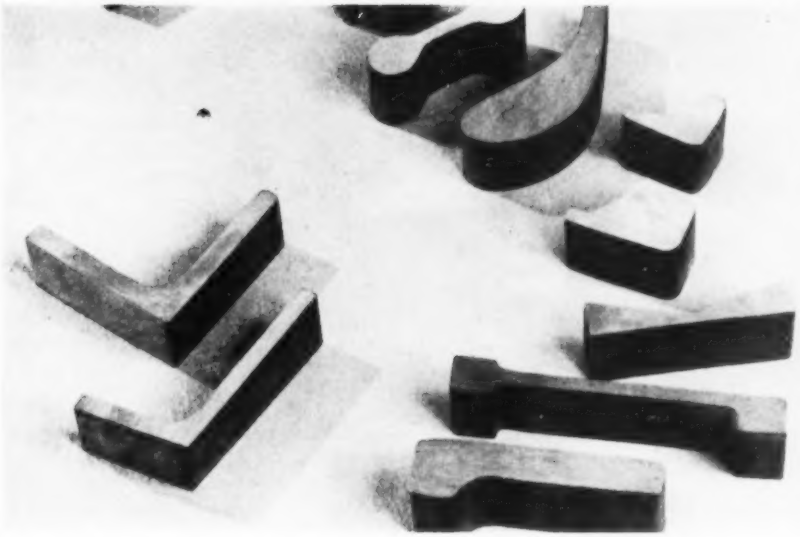
Allis-Chalmers Mfg. Co.—**242**
Alloy Engineering & Casting Co.—**1101**
American Gas Association—**854 A to F, 843 G to K**
American Wheelabrator & Equipment Corp.—**632**
Arcair Co.—**1445**
Bakelite Div., Union Carbide & Carbon Corp.—**653**
Exomet, Inc.—**1539**
Metallizing Co. of America—**1456**
National Carbon Co.—**653**
Spencer Turbine Co.—**843-K**
Standard Electrical Tool Co.—**1028**

Die Casting Machines

ABC Die Casting Machine Co.—**2030**
Kux Machine Co.—**1001**

Alloying and Refining Agents

Cooper Metallurgical Associates—**316**
Electro Metallurgical Co.—**653**
Exomet, Inc.—**1539**
Metallizing Co. of America—**1456**
Titanium Alloy Mfg. Div., National Lead Co.—**260**
Vanadium Corp. of America—**320**



Extruded Sections in Stainless Steels and Toolsteels Made by Allegheny Ludlum Steel Corp.

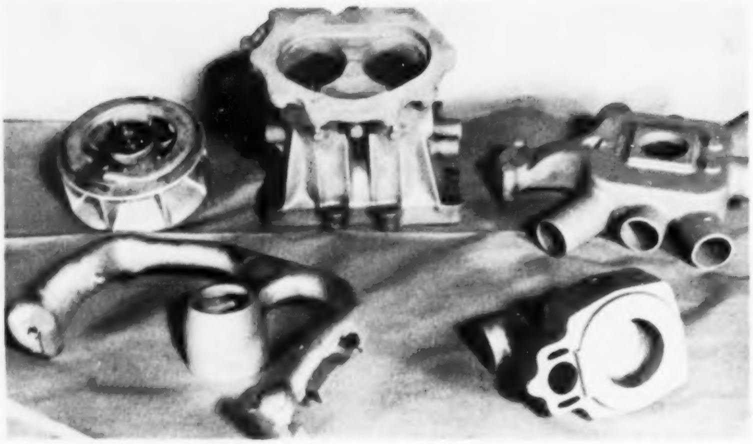
Metallic Parts and Components

While steel parts made by cold extrusion, both forward and backward, were innovations which attracted much attention at the National Metal Exposition in 1953, the news of the year in 1954 will probably be the extruded bars of stainless and toolsteels exhibited by Allegheny Ludlum Steel Corp. Some of the sections are shown in the accompanying photograph. While all could be made in a rolling mill, some (like an angle iron) require several passes in expensive rolls, which cannot economically be turned for a special shape unless a large tonnage is ordered. An extrusion die is very cheap in comparison. Stiff alloys have been successfully extruded into tubing, especially with the help of a glass lubricant, but irregular moldings and other forms so readily made in the softer metals have not before been available. Yet, it is all the more necessary that the hard alloys, loaded with scarce elements, be produced close to shape – not only to cut machining cost, but to minimize scrap and chip production. (For a picture story about the extrusion of steel propeller blades – a tapered tube of variable wall thickness – see June '54, p. 100.)

Should your work be connected with high-speed aircraft and jet engines, or if you have similar problems requiring titanium metal, you should visit the booth of Consolidated Industries and look at the exhibit of forged titanium and beryllium parts – as well as aircraft forgings of the old reliable steels, bronzes and aluminum alloys. Worcester Pressed Steel Co. is also proud of its success in stamping and deep drawing titanium sheet. (At present this company is making a comprehensive investigation for Army Ordnance.) Unalloyed titanium works about like stainless steels at room temperature; alloyed sheet may have to be warmed first (like magnesium). Annealing after every draw is apparently necessary. The major trouble appears to be lubrication – it is almost impossible to prevent pick-up and scoring.

Light will be thrown on one important phase of the stamping industry by HPL Mfg. Co. Metals engineers have frequently decided that marked economies may be derived by converting a forging, casting or machined part into an assemblage of stampings, but have not carried the matter further because of a fixed idea that tools, dies and set-up are so costly that long runs are necessary. HPL Mfg. Co. will demonstrate facilities for "short-run tooling methods" to make stampings in quantities as low as a few experimental parts up to, say, 20,000 pieces.

Foundry products, as usual, may be inspected in great number, ranging all the way from the old reliable gray iron piece cast in sand to nonferrous pieces of much closer dimensions cast in dies, refractory alloys made by investment molding, or



Typical Magnesium Castings, Conforming to Rigid Standards, by Hills-McCanna Co.

spheroidal graphite iron made by shell molding. To use a well-worn phrase, the foundry industry is on the march!

Hills-McCanna Co. will exhibit light-alloy castings of the magnesium-aluminum-zinc alloys. Three of these compositions (AZ 92 A, AZ 63 A and AZ 91 A) form the majority of production of the new foundry where, as the saying is, "only the sand is inhibited". Accurate coremaking is especially necessary in the thin-walled parts required for aircraft; ultra modern process control and final inspection methods are a matter of course.

High-strength, high-conductivity castings and forgings of hard copper alloy (primarily for resistance welding electrodes on clamps and other current-carrying parts) will be on display by WW Alloys, Inc., Div. of Fansteel Metallurgical Corp.

American Cast Iron Pipe Co. will also display a variety of centrifugally cast parts, including stainless steel rolls, hydraulic cylinders and rams and tubing of various sections.

Die Castings – About three years ago a team of men representing both management and labor in Great Britain's die-casting industry toured representative American plants, and their report (Sept. '53, p. 138) indicated certain fields wherein we are ahead. One most gratifying aspect for us is that aluminum die castings have doubled in tonnage in America since 1949. Several firms will demonstrate the reasons in their exhibits at the Metal Show. For example, Precision Castings Co., Inc., will show many die-cast parts going into automatic transmissions for automobiles, as well as some functional and decorative parts already on order for 1955 models. However, other large uses range all the way from floor plates to sewing machines, shell fuzes to cake mixers.

Pressco Casting & Mfg. Corp. has mastered the somewhat more difficult problems connected with brass and bronze – either pressure die casting or gravity casting in permanent and semipermanent molds. Some of the newer products on display will be spur and bevel gears up to 5 in. diameter, cast in aluminum bronze or nickel-aluminum bronze with pitch line tolerances of ± 0.007 to 0.010 in. If this is not good enough the teeth can be shaved or coined. Advantages are low unit cost and long life. An interesting combination of permanent molds and shell molded cores produces valve bodies, pump impellers, and Venturis with unusually smooth interior surfaces.

Universal Castings Corp. will feature thin-walled brass and bronze castings "vacuum cast" – particularly impellers for aircraft fuel pumps, and hydraulic transmission parts requiring airfoil blades.

Bonded-in or bonded-on parts will be featured by Al-Fin Division of Fairchild Engine and Airplane Corp. The "Al-Fin Process" (March '49, p. 326), it may be remembered, was designed to improve heat transfer from air-cooled gas engine cylinders by bonding a great number of aluminum fins to the steel liner. The cleaned steel (or nickel or titanium or iron) is briefly dipped in molten aluminum and placed in a properly prepared mold which is immediately poured with the desired light alloy. An excellent bond forms with the coated surface. Cast aluminum or magnesium airfoils with bonded-in steel shafts for guided missiles will be on display. Also cast aluminum generator housings with bonded-in laminations and tubing for coolants. Sole plates for pressing irons are also die-cast against stainless steel bottoms.

Investment castings will be shown by several firms in a wide variety of sizes, shapes, metals and alloys. Arwood Precision Casting Corp., for example, believes that its exhibit of 500 such castings will illustrate to any visitor the savings in time and money which can be made by this process.

Casting Engineers, Inc., also will demonstrate the process in a step-by-step way, to emphasize the close tolerances attainable; many designs are being produced regularly, ready for assembly, at half the cost of machining alone, when made in the old-fashioned way.

Whereas wax is the usual material for the patterns, other materials have distinct possibilities. For example, Precision Metalsmiths, Inc., believes that polystyrene is an ideal material for patterns during developmental work. It cuts much like soft metal with high speed or carbide tools. You build up your pattern, test its castability in whatever metal or alloy thought suitable, and then you are ready to go. As the Metalsmith says –"You can't cast a blueprint" . . . . Frozen mercury (Jan. '50, p. 73) also has pronounced advantages for patterns, being so much more rigid than waxes or synthetics. It is the favorite of Kolcast Industries, Inc., which will display what is believed to be the largest investment casting in stainless steel ever made.

New molding processes will also be shown in considerable number. For example, the Ohio Steel Foundry Co. will display stainless steel and heat resisting steel castings made by shell molding (April '54, p. 102). Lynchburg Foundry Co. will have a few items produced in a million-dollar department for shell molding gray iron and spheroidal graphite irons at the rate of 100 tons a day. Howard Foundry Co. also has added the last-mentioned item to its general line of foundry products.

Heat and corrosion resistant castings made by new processes (including ceramic molds) will be exhibited by Alloy Engineering and Casting Co., in addition to the regular line of furnace parts and heat treating fixtures. In this same field is Driver-Harris Co. with "Nichrome" and "Chromax" castings. Janney Cylinder Co. will show castings of "Alloy V 2 B", patented by Cooper Alloy Foundry Co., for high corrosion and wear resistance but without the galling characteristics usually associated with high chromium-nickel steels. (V 2 B is a high silica, 19-10 Cr-Ni alloy, plus 2% Cu, 3% Mo, and 0.15% Be.) Visitors who have corrosion problems with shaft sleeves, pump liners, pump castings and impeller rings or valve disks might find their solution right here. E.E.T.

Classified List of Exhibitors and Booth Numbers

Forgings

Allegheny Ludlum Steel Corp.—**336**
Chase Brass and Copper Co.—**302**
Consolidated Industries, Inc.—**1524**
Fansteel Metallurgical Corp.—**1559**
National Cored Forgings Co., Inc.—**1236**
Nelson Stud Welding Div., Gregory Industries, Inc.—**415**
Ohio Seamless Tube Div., Copperweld Steel Co.—**744**
Titanium Metals Corp. of America—**226**
WW Alloys Inc., division of Fansteel Metallurgical Corp.—**1559**

Castings

Al-Fin Division, Fairchild Engine & Airplane Corp.—**2270**
Allegheny Ludlum Steel Corp.—**336**
Alloy Engineering & Casting Co.—**1101**
American Brake Shoe Co., Electro-Alloys Div.—**762**
American Cast Iron Pipe Co.—**1020**
Arwood Precision Casting Corp.—**1254**
Bean & Co., Morris—**2118**
Cadmet Corp.—**2328**
Casting Engineers, Inc.—**1746**
Chase Brass & Copper Co.—**302**
Driver-Harris Co.—**2267**
Fansteel Metallurgical Corp.—**1559**
General Alloys Co.—**652**
Haynes Stellite Co.—**653**
Hills-McCanna Co.—**2301**
Hitchcock & Sons, Inc., R. C.—**2017**
Hitchiner Mfg. Co., Inc.—**1412**
Howard Foundry Co.—**1227**
Janney Cylinder Co.—**1767**
Kolcast Industries, Inc.—**1927**
Lynchburg Foundry Co.—**2067**
Michiana Products Corp.—**1759**
Misco Fabricators, Inc.—**1730**
Ohio Steel Foundry Co.—**1435**
Precision Castings Co., Inc.—**1430**
Precision Metalsmiths, Inc.—**2045**
Presso Casting & Mfg. Corp.—**2215**
Shenango-Penn Mold Co.—**2112**
Universal Castings Corp.—**2148**
WW Alloys Inc., Div. of Fansteel Metallurgical Corp.—**1559**
Yale & Towne Mfg. Co., Powdered Metal Products Div.—**2260**

Stampings

Allegheny Ludlum Steel Corp.—**336**
Chase Brass & Copper Co.—**302**
Chicago Screw Co.—**2223**
Enamelstrip Corp.—**346**
HPL Mfg. Co.—**1418**
Phoenix Products Co.—**1449**
Rigidized Metals Corp.—**1425**
Schnell Tool & Die Corp.—**2241**
Stimpson Co., Inc., Edwin B.—**1701**
Tinnerman Products, Inc.—**1208**
Waldes Kohinoor, Inc.—**1556**
Worcester Pressed Steel Co.—**2001**

Tubing and Other Mill Shapes

Allegheney Ludlum Steel Corp.—**336**
Alloy Metal Wire Co., Div. of H. K. Porter Co., Inc.—**1645**
American Cast Iron Pipe Co.—**1020**
American Nickeloid Co.—**2314**
Avon Tube Div., Higbie Mfg. Co.—**1939**
Babcock & Wilcox Co.—**236**
Chase Brass & Copper Co.—**302**
Cold Metal Products Co.—**141**
Copperweld Steel Co., Steel Div.—**744**
Enamelstrip Corp.—**346**
H & H Tube & Mfg. Co.—**1502**
Misco Fabricators, Inc.—**1730**
Ohio Seamless Tube Div., Copperweld Steel Co.—**744**
Ohio Steel Foundry Co.—**1435**
Precision Extrusions—**2217**
Superior Tube Co.—**1667**
Titanium Metals Corp. of America—**226**

Powder Metals and Parts Production

Adamas Carbide Corp.—**1411**
Allegheny Ludlum Steel Corp.—**336**
Amplex Div., Chrysler Corp.—**1335**
Baldwin-Lima-Hamilton Corp.—**1065**
Carboloy Dept., General Electric Co.—**1540**
Cooper Metallurgical Associates—**316**
Elastic Stop Nut Corp. of America—**2023**
Fansteel Metallurgical Corp.—**1559**
Firth Sterling, Inc.—**315**
General Electric Co.—**1060**
Kennametal, Inc.—**326**
Kux Machine Co.—**1001**
National Radiator Co., Plastic Metals Div.—**1911**
Stokes Machine Co., F. J.—**2167**
Westinghouse Electric Corp.—**360**
Willey's Carbide Tool Co.—**2146**
WW Alloys Inc., division of Fansteel Metallurgical Corp.—**1559**
Yale & Towne Mfg. Co., Powdered Metal Products Div.—**2260**

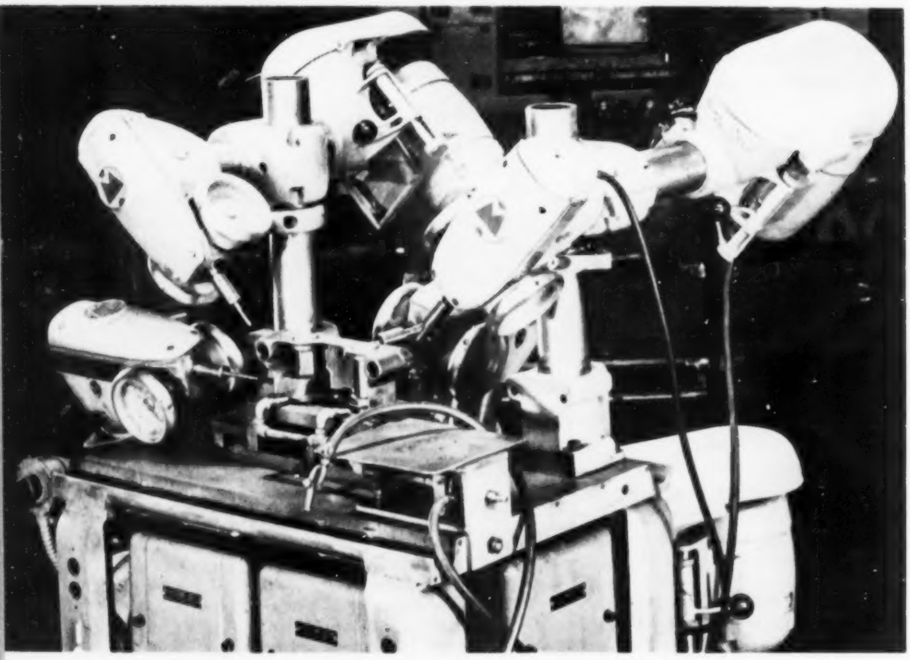
Machining, Forming, Tooling

Versatility, speed and power of modern metal-forming and machining equipment have kept pace – and it is a lively one – with industry's demands for improved quality combined with lower unit costs through increased output per man-hour and reduced manual effort. The limitless exhibits at the National Metal Exposition keyed to this theme appear more striking each year, with 1954 slated to be no exception.

Tougher materials to machine and form, products of the "electrojetomic" age, have further tested the ingenuity of equipment designers and have put added pressure on suppliers of cutting tools, dies, lubricants, coolants, toolholders and related accessories. The Metal Show bears witness that they have met the test.

In broad perspective, basic machining operations are gradually becoming integrated, both with themselves and with other processing phases.

Versatility Is a Must in Today's Tools. Here is a novel set-up of five drill heads and lead screw tappers for tapping five holes simultaneously from five different angles in a gray iron casting. Devised by Magna Engineering Corp., for Production Engineering Co., Berkeley, Calif., the system boosted production from 30 to 120 per hr., and on the basis of 700 pieces per week paid for itself in 46 weeks



The term "automation" is being used rather loosely to describe this (March '54, p. 65). Because of its close identification with the high-volume plants, it is regarded with suspicion by many an average operator. Approaching the problem realistically, the Expert Die & Tool Co., Inc., through its new Automation Machine Div., is introducing what it calls "multipurpose special machine tools". They comprise nothing more than standard machine-tool components – index tables, slide tables, index drums, standard units for drilling, milling, boring, tapping and threading; standard columns, hydraulic pump and control elements – properly grouped and fixtured for specialized production requirements. Short runs can be handled without too much worry

High-Speed Carbide Tool Grinder With Fluid Vaporizer Attachment Supplying Coolant Vapor Through Ports in the Wheel Guard. Two speed ranges are possible, 10,800 rpm. for maximum stock removal, 3600 rpm. for grinding tool radii. Builder is Metalloid Equipment, Inc.

over equipment amortization, since the machine set-up can be modified and refixtured handily for the next assignment.

Manufacturers in the moderate-volume range – and they are, of course, far in the majority – should be attracted to the standardized, packaged, precision power drill units now offered in three sizes from ¾ to 5 hp. by the Drill Unit Div., Rockwell Mfg. Co. Because of their sealed construction, built-in limit switches and broad range of speeds and traverse, they can be easily incorporated into an automatized line, while retaining adaptability for quick change and retooling. Rockwell's Delta Power Tool Div., incidentally, will unveil its initial entry into the metalworking lathe field, an 11-in. cabinet model with variable-speed drive, 24-in. capacity between centers and accommodating up to a 1-in. collet. It has been under development for five years.

Another self-contained automatic drill unit, with wide variability of speed and requiring only two connections – electric power and shop air – has been designed by the Dumore Co. with the idea of reducing set-up time and providing adaptability to a wide variety of jobs. It can be converted readily to tapping, reaming, deburring, centering, counterboring, spot facing or hollow milling.

Assembly of standardized punch and die sets into different operating positions by specially drilled templets permits their removal after a perforating run has been made, for later re-use in a different arrangement in another templet. Thus, as S. B. Whistler & Sons, Inc. explains, the punch and die sets do not become expendable tools on a single job, being rather like stock items, always available for future use. The system is called a "magnetic perforating die".

Operators of automatic screw machines will be intrigued with the cost-savings potential of a novel single-spindle design by Porter-McLeod Machine Tool Co., Inc., on which both ends of a workpiece may be machined simultaneously, thus eliminating virtually all secondary operations.

Rugged demands on tools imposed by some of the newer alloys for high-temperature service in jet engines have stimulated the development of new grades of carbides which will stand up under severe punishment. Combinations of four and even five different metal carbides have been found to provide exceptional shock and wear resistance on heavy cuts in tough alloys. Adamas Carbide Corp., for example, has perfected four such "premium" grades, for difficult machining work, along with two others for rough service in rock bits.

Carbide tool inserts currently are being fashioned into literally hundreds of shapes, both standard and special. Adamas has a new preformed milling cutter blade with a helix formed in the face and a helical clearance formed on the top. Back and bottom of the blade are flat so it can be brazed into a straight axial gash pocket. Hence no heating or twisting of the blade is necessary and brazing is simplified.

Some of the myriad of carbide blanks to be displayed by Carboloy Dept. of General Electric Co. include circular form or fluted, blanks with drilled holes or plugs, odd-shaped nibs and bushings with broached holes, cylindrical and triangular sections, extruded rod, grooving tools.

Ever-widening applications for carbide tools have accentuated the requirement for grinding equipment and the diamond-impregnated wheels conventionally used to sharpen this type of tool. Concern over the mounting demand for diamond bort in relation to the available supply has prompted extensive research into electrolytic methods for assisting grinding or shaping (Aug. '53, p. 161). Likewise investigations are being pursued into other sharpening procedures which would dispense with the need for diamond bort altogether. The latter include electro-arcing and electro-sparking processes.

Tool grinding machines will be displayed in profusion at the National Metal Exposition. One unusual model is a twin-wheel precision grinder (in operation) by Standard Electrical Tool Co. Claimed to be the only two-man machine on the market, its side-by-side wheels operate in the same direction and are reversible. Savings as high as 25% in wheel cost are claimed from this twin arrangement.

A high-speed grinder for roughing and finishing single-point carbide tools will be demonstrated by Metalloid Equipment, Inc. For maximum stock removal a high speed of 10,800 rpm. is used; for grinding radii a low speed of 3600 rpm. Power is supplied through a frequency converter for the upper speed range, and through a transformer for low speed. The grinding wheel is a diamond type, bonded with electroplated pure nickel.

A relative newcomer to the tool metals family is the so-called "heavy metal", a mixture of powders, up to 95% tungsten and the balance nickel and copper. Originally designed as a shielding material against X-rays (it is 60% heavier than lead), new uses lately have been cropping up in the tooling category. Firth Sterling, Inc. has been digging into such applications and reports one instance where heavy metal was installed as an anvil component or insert in hot upsetting the ends of Type 430 stainless steel rods to form the root sections of turbine blades. The anvils operate at 1750° F. and are subject to severe oxidation, thermal shock and compressive stress. A change to heavy metal inserts boosted life between grinds from 350 upsets to 2400.

Coolants, cutting oils, lubricants and hydraulic fluids are all being modified and improved to attune them to the tempo of today's machining and forming practices. An instance is a new water-soluble coolant concentrate by Johnson's Wax, dubbed "TL-131". Its effectiveness derives from new wetting

Classified List of Tooling Exhibitors and Booth Numbers

Toolsteels and Tool Materials

Adamas Carbide Corp.—**1411**
Allegheny Ludlum Steel Corp.—**336**
Black Drill Co.—**1511**
Carboloy Dept., General Electric Co.—**1540**
Dow Chemical Co.—**620**
Firth Sterling, Inc.—**315**
Howard Foundry Co.—**1227**
Milne & Co., A.—**216**
Portage Double Quick Tool Co.—**1535**
Uddeholm Co. of America, Inc.—**201**
Willey's Carbide Tool Co.—**2146**

Cut-Off Equipment

Allegheny Ludlum Steel Corp.—**336**
Allison Co.—**142**
Campbell Machine Div., American Chain & Cable Co.—**1228**
Delta Power Tool Div., Rockwell Mfg. Co.—**1053**
De Sanno & Son, Inc., A. P.—**2139**
Heller Machine Co.—**1116**
Manco Mfg. Co.—**1522**
Manhattan Rubber Div.—**1201**
Metal Removal Co.—**235**
Motch & Merryweather Machine Co.—**2160**
Porter-Cable Machine Co.—**1443**
Wells Mfg. Corp.—**219**

Machine Tools and Accessories

Ace Drill Bushing Co. Inc.—**2255**
Acme Tool Co.—**1005**
Adamas Carbide Corp.—**1411**
Allegheny Ludlum Steel Corp.—**336**
American Positive Grip Vise Corp.—**1545**
American Pullmax Co., Inc.—**1253**
Black Drill Co.—**1511**
Boice-Crane Co.—**1729**
Buck Tool Co.—**460**
Campbell Machine Div., American Chain & Cable Co.—**1228**
Challenge Machinery Co.—**2130**
Commander Mfg. Co.—**1309**
Delta Power Tool Div., Rockwell Mfg. Co.—**1053**
De Sanno & Son, Inc., A. P.—**2139**
Diamond Machine Tool Co.—**1260**
Drill Unit Div., Rockwell Mfg. Co.—**1053**
Dumore Precision Tools—**1407**
East Shore Machine Products Co.—**1448**
Expert Die & Tool Co., Expert Automation Machine Div.—**1330**
Elox Corp. of Michigan—**1612**
Firth Sterling Inc.—**315**
Graham Machine Tool Co.—**1025**
Heath Engineering Co.—**2340**
Heller Machine Co.—**1116**
Jiffy Tool Supply Co., Inc.—**1543**
Lempco Products, Inc.—**1460**
Logan Engineering Co.—**1617**
M.B.I. Export & Import, Ltd.—**125**
Maddaus Molders & Co., Inc.—**2329**
Mead Specialties Co.—**2011**
Metal Removal Co.—**235**
Motch & Merryweather Machine Co.—**2160**
Portage Double Quick Tool Co.—**1535**
Porter-McLeod Machine Tool Co., Inc.—**301**
Ransohoff, Inc., N.—**215**
Richards Co., J. A.—**1453**
Schrader's Sons Div., A.—**1127**
Service Machine Co.—**1611**
Sheldon Machine Co., Inc.—**1059**
Stanat Mfg. Co.—**1659**
Standard Electrical Tool Co.—**1028**
Swiss Agie Corp.—**1465**
Torrington Mfg. Co., Wire Forming Machinery Div.—**2060**
Tubular Micrometer Co.—**2236**
Volz Machinery Co., H. J.—**2256**
Versa-Mil Co.—**1359**
Waldes Kohinoor, Inc.—**1556**
Walker-Turner Div.—**2117**
Wells Mfg. Corp.—**219**

Presses and Brakes

Allis-Chalmers Mfg. Co.—**242**
Atlas Press Co.—**2057**
Baldwin-Lima-Hamilton Corp.—**1065**
Dake Engine Co.—**1749**
Diamond Machine Tool Co.—**1260**
Dreis & Krump Mfg. Co.—**458**
Hydraulic Press Mfg. Co.—**109**
Lempco Products, Inc.—**1460**
O'Neill-Irwin Mfg. Co.—**1215**
Precision Welder & Flexopress Corp.—**265**
Rodgers Hydraulic, Inc.—**419**
Verson Allsteel Press Co.—**1316**
Wallace Supplies Mfg. Co.—**310**

Cutting and Forming Oils and Lubricants

Aldridge Industrial Oils, Inc.—**1424**
Cities Service Oil Co.—**1216**
Gulf Oil Corp.—**1560**
Houghton & Co., E. F.—**1010**
Johnson's Wax—**1326**
Kerns Co., L. R.—**1440**
Metal Lubricants Co.—**2056**
Shell Oil Co.—**2359**
Socony-Vacuum Oil Co., Inc.—**1546**
Standard Oil Co.—**2036**
Texas Co.—**1529**
Turco Products, Inc.—**2024**

Punches and Dies

Adamas Carbide Corp.—**1411**
Allegheny Ludlum Steel Corp.—**336**
Diamond Machine Tool Co.—**1260**
Firth Sterling, Inc.—**315**
Lempco Products, Inc.—**1460**
Industrial Tectonics, Inc.—**2249**
National Lead Co.—**260**
Schnell Tool & Die Corp.—**2241**
Service Machine Co.—**1611**
Whistler & Sons, Inc., S. B.—**135**

Portable and Bench Tools

Acme Tool Co.—**1005**
American Positive Grip Vise Corp.—**1545**
Challenge Machinery Co.—**2130**
Chicago Tool and Engineering Co.—**2253**
Electro Arc Mfg. Co.—**1465**
Green Instrument Co.—**1925**
H & H Research Co.—**1005**
Metal Removal Co.—**235**
O'Neill-Irwin Mfg. Co.—**1215**
Porter-Cable Machine Co.—**1443**
Schmidt, Inc., George T.—**1362**
Skil Corp.—**2201**
Starrett Co., L. S.—**2101**
Tubular Micrometer Co.—**2236**

agents with low surface tension which put coolant at the very work point; temperatures are cut as much as 300° in comparison with conventional coolants.

E. F. Houghton & Co. will sound a warning for Show visitors against the fire and explosion hazards inherent in petroleum-base hydraulic fluids in equipment located near open flames, extreme heat, sparks, or molten metal, should hydraulic lines accidentally break. Houghton, of course, can supply nonflammable fluid and it is generally accepted in hydraulic systems of die-casting machines, welding equipment, hydraulic forging presses and hydraulic foundry devices.

In handling coolants or other liquids containing abrasive material, a gear pump is apt to take a severe beating. East Shore Machine Products Co. has done something about it by designing a pump with impeller gears ground on a 2° taper after hardening, to match a tapered recess in the housing. As wear occurs, spring tension on a floating back-up plate forces the gears into the tapered bore of the case. Latest model of the pump will deliver up to 18 gal. per min. at 1000 rpm. shaft speed, at pressures ranging up to 250 psi.

Reversing the usual procedure of conveying the work to the machine, A. P. de Sanno & Son, Inc. has mounted its new abrasive dry cutoff machine on a truck, so it can be moved about for production or maintenance. The machine mounts an 18-in. bonded abrasive blade, driven by a 10-hp. motor, and will cut steel up to 2⅜ in. OD and tubing up to 4 in. OD. The name? What else but "Traveler"?

The complete list of machining and forming equipment assembled for the edification of Show visitors would include lathes, milling machines, press brakes, folder brakes, punch presses, spring winders, sheet rollers, notchers and rod parters. A good opportunity to compare U.S. and foreign machine designing talents will be provided by a stop at the booth of M.B.I. Export & Import Ltd.

If you would like to see large circles being ripped out of steel plate at a speed of 32 ft. per min., American Pullmax Co., Inc. will show you how it is done with the aid of a power feed attachment on its largest sheet and plate cutting machine.

Finally, if your interest is confined to nothing more than discovering a better way to mark metals, tools or parts with identifying symbols, Geo. T. Schmidt, Inc. will demonstrate two hydraulic and pneumatic marking machines; Green Instrument Co., Inc. a pantographic electric arc etching attachment; and Electro Arc Mfg. Co. a combination etcher and demagnetizer for etching, magnetizing, demagnetizing and even resistance soldering.

Tired yet? A.H.A.

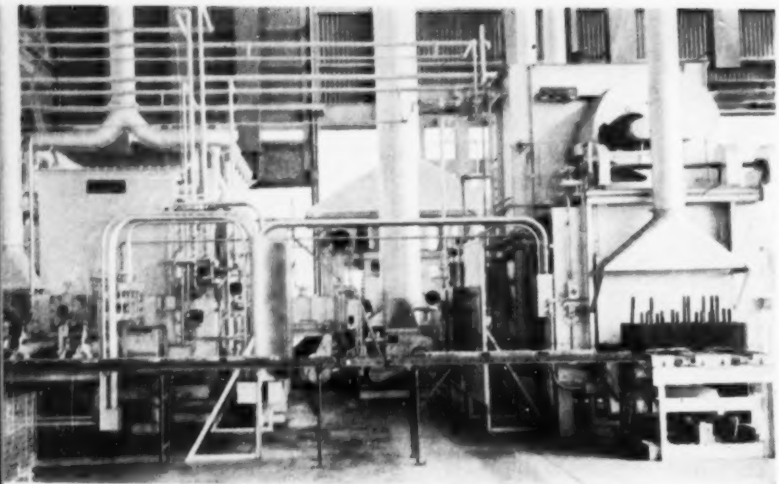
Heat Treating

Building a heat treating "package" seems more than ever the aim of furnace manufacturers and others concerned with the science of enhancing the properties of a metal through application of heat. The dirt and drudgery of former days have given way to pushbuttons, to "sealed cycles" and "pressurized processing".

These are, in fact, the precise words which Dow Furnace Co. uses to describe its new controlled-atmosphere batch-type furnaces for gas carburizing, carbo-nitriding, clean hardening and carbon restoration, scheduled to be on display at the Metal Show. Batch furnaces are far from being written off by heat treating departments, despite the glowing accomplishments of continuous line set-ups. Their quick adaptability to a variety of heat treating assignments and their relatively lower initial investment make them a wise selection in many instances.

Latest model of Holcroft & Co.'s gas-fired radiant-tube pusher furnace combines completely automatic operation with the most modern safety devices to give a maximum safety margin for controlled-atmosphere furnaces. In one arrangement, for processing parts loaded either on fixtures or in baskets, the installation is laid out in the form of a rectangle so that the furnace trays are in a closed circuit and can be loaded and unloaded easily by one furnace operator. The equipment includes a pusher-type furnace in which the work may be clean hardened, carbo-nitrided or carburized, and in addition a hot salt quench for marquenching and a recirculating pusher-type draw furnace for tempering. The complete cycle is automatic.

Improvements have been made in reciprocating or shaker-hearth controlled-atmosphere heat treating furnaces, with the idea of giving more exact atmosphere control, increasing capacity and reducing the amount of manual effort required to run them. American Gas Furnace Co. has rather fully redesigned both its reciprocating hearth and con-



Arranged in the Shape of a Rectangle, This Combination of Pusher-Type Heating Furnace, Quench and Draw Furnace Is Completely Automatic. Trays or fixtures are in a closed circuit, requiring the services of just a single operator for loading. It is adaptable to clean hardening, carbonitriding and carburizing. (Holcroft & Co.)

tinuous rotary retort furnaces with these goals in mind. The former type has a movable alloy hearth within a sealed stationary muffle. The discharge throat of the muffle seals directly into the quenching medium. Life of alloy structural elements is increased because the floor is not quenched intermittently by the incoming cold work, thus eliminating the thermal shock and stress to which it was formerly subjected. Quieter operation is realized with the use of a simplified drive mechanism and by the reciprocation of only the relatively light work-conveying hearth. This type of furnace is now built in capacities up to 600 lb. per hr. The improved rotary retort furnaces will handle up to 800 lb. per hr.

Standard sizes of shaker-hearth furnaces built by Hevi Duty Electric Co. accommodate up to 175 lb. of small parts per hr., featuring automatic and continuous operation. One installation in the plant of an electric appliance manufacturer saved $12,000 in the first year of operation, processing 50,000 small springs every 7 hr., with only one operator needed part time to fill the supply hopper. Feed to the hearth is automatic, as is removal from the quench.

Modifications in the design of "top hat" bright annealing furnaces introduced by Continental Industrial Engineers, Inc., include a change in the central heating unit aimed at liberating a substantial amount of heat in the center of the coils of metal under the inner cover. The latter is specially shaped to provide space for this center auxiliary burner. In one recent installation for nonferrous strip annealing, heating time was reduced by 20%, thereby boosting production accordingly. The same arrangement has been used on steel mill installations for bright annealing coils of 12,000 to 15,000 lb. of strip.

Gas generators and purifiers for use in connection with heat treating in controlled furnace atmospheres will be demonstrated by Baker & Co., Inc. One model of generator produces pure nitrogen with a controllable hydrogen content by reacting ammonia with air in the presence of an Engelhard catalyst. The apparatus generates a gas completely free from oxygen, comprising only nitrogen, hydrogen and water vapor. The hydrogen content can be varied within close limits anywhere from 0.25 to 25%. Baker's Deoxo gas purifiers and driers are made in several models, for removal of up to 3% oxygen impurities in different gas mixtures.

In the field of heating furnaces, Gas Appliance Service, Inc., has combined its gas Roto-Flame furnace with a mechanical hopper-feed unit and slat conveyer for fully automatic heating of 2 in. on the ends of ⅝-in. steel bars to be subsequently bent and upset. One installation showed a gain of 50% in number of pieces heated per hr., with no increase in labor.

To prove that the quenching power of molten salt at 400° F. equals or surpasses that of agitated oil at 120° F., Ajax Electric Co. will operate one model of its new "cataract quench" furnace and let the visitor judge for himself. Quenching machines in improved versions of both the press and roller types will be on display at the booth of Gleason Works. Latest models of flame hardening equipment for gear teeth also will be shown.

A neatly designed motor-generator control and master induction heating station, adaptable to forging, hardening, brazing or annealing where deep concentration of heat is desired, will be a highlight of the exhibit of Lindberg Engineering Co. It can be tied in with M-G sets providing frequency cycles of 960, 3000 or 9600 and power input ranging from 20 to 1250 kw. The control panel incorporates a system of "check lights" which maintains constant super-

vision of air and water temperatures, high-voltage interlocks, water flow and other operating factors of both generator and work stations. Weltronic Induction Heating Corp. will have on display totally enclosed water-cooled motor-generators for induction heating installations ranging from 10 to 150 kw.

Claimed to be the largest magnesium billet heater ever constructed and currently operating in conjunction with a 5500-ton extrusion press, is a new unit from the design boards of Magnethermic Corp. The furnace will be depicted in operation by means of color illustrations. It is rated at 1500 kw. and preheats 12,000 lb. of 15 x 40-in. billets hourly.

Combination variable-pressure oil-gas burners with adjusting levers permitting changes in flame shape from short and bushy to long and narrow, or at intermediate points, may be inspected at headquarters of Hauck Mfg. Co. Single-valve control of air-oil ratio and capacity is provided in the combustion air line serving a group of the burners. The varying air pressure is then cross connected to an oil-air ratio regulator. A.H.A.

Classified List of Exhibitors and Booth Numbers

Commercial Heat Treating

Electric Furnace Co.—**636**
Ferrotherm Co.—**2247**
Kemp Mfg. Co., C. M.—**854-B**
Lindberg Engineering Co.—**662**
Scott & Son, Inc., C. U.—**456**

Fuel-Fired Furnaces and Special Heating Equipment

American Gas Association—**854 A to F, 843 G to K**
American Gas Furnace Co.—**843-H**
Commercial Shearing & Stamping Co.—**2233**
Continental Industrial Engineers, Inc.—**843-G**
Dean Products, Inc.—**1401**
Delaware Tool Steel Corp.—**2322**
Dow Furnace Co.—**1041**
Eclipse Fuel Engineering Co.—**854-D**
Electric Furnace Co.—**636**
Gas Appliance Service, Inc.—**854-A**
Gas Machinery Co.—**854-C**
Glo-Quartz Electric Heater Co., Inc.—**1459**
Harmon & Co.—**2233**
Hauck Mfg. Co.—**2124**
Holcroft & Co.—**1220**
Hones Inc., Charles A.—**854-E**
Industrial Heating Equipment Co.—**1755**
Ipsen Industries, Inc.—**819**
Jet Combustion, Inc.—**2235**
Kemp Mfg. Co., G. M.—**854-B**
Leeds & Northrup Co.—**442**
Lindberg Engineering Co.—**662**
Linde Air Products Co.—**653**
Salem-Brosius, Inc.—**241**
Selas Corp. of America—**854-F**
Sunbeam Corp.—**448**
Surface Combustion Corp.—**714**
Tranter Manufacturing, Inc.—**1353**
Westinghouse Electric Corp.—**360**

Induction Heaters

Allis-Chalmers Mfg. Co.—**242**
Electric Furnace Co.—**636**
General Electric Co.—**1060**
Induction Heating Corp.—**1336**
Lepel High Frequency Labs., Inc.—**1031**
Lindberg Engineering Co.—**662**
Magnethermic Corp.—**1660**
Ohio Crankshaft Co.—**160**
Scientific Electric Div., "S" Corrugated Quenched Gap Co.—**147**
Weltronic Induction Heating Corp.—**163**
Westinghouse Electric Corp.—**360**

Electric Furnaces

Ajax Electric Co.—**752**
Continental Industrial Engineers, Inc.—**843-G**
Cooley Electric Mfg. Corp.—**1649**
Delaware Tool Steel Corp.—**2322**
Electric Furnace Co.—**636**
General Electric Co., Apparatus Sales Div.—**1060**
Harper Electric Furnace Corp.—**1919**
Hevi Duty Electric Co.—**247**
Holcroft & Co.—**1220**
Ipsen Industries, Inc.—**819**
Leeds & Northrup Co.—**442**
Lindberg Engineering Co.—**662**
Salem-Brosius, Inc.—**241**
Sentry Co.—**445**
Sunbeam Corp.—**448**
Upton Electric Furnace Co.—**1118**
Westinghouse Electric Corp.—**360**

Atmosphere Preparation Equipment

American Gas Association—**854-A to F, 843-G to K**
Baker & Co., Inc.—**1327**
Continental Industrial Engineers, Inc.—**843-G**
Delaware Tool Steel Corp.—**2322**
Dow Furnace Co.—**1041**
Electric Furnace Co.—**636**
Hevi Duty Electric Co.—**247**
Holcroft & Co.—**1220**
Industrial Heating Equip. Co.—**1755**
Ipsen Industries, Inc.—**819**
Lindberg Engineering Co.—**662**
Salem-Brosius, Inc.—**241**
Surface Combustion Corp.—**714**
Tenney Engineering, Inc.—**2330**
Waukee Engineering Co., Inc.—**1121**
Westinghouse Electric Corp.—**360**

Quenching Equipment and Mediums

Ajax Electric Co.—**752**
Aldridge Industrial Oils, Inc.—**1424**
American Cyanamid Co.—**132**
American Gas Furnace Co.—**843-H**
Bell & Gossett Co.—**441**
Cincinnati Sub-Zero Products Co.—**1630**
Cities Service Oil Co.—**1216**
Continental Industrial Engineers, Inc.—**843-G**
Dean Products, Inc.—**1401**
Electric Furnace Co.—**636**
Gleason Works—**454**
Gulf Oil Corp.—**1560**
Houghton & Co., E. F.—**1010**
Industrial Heating Equip. Co.—**1755**
Ipsen Industries, Inc.—**819**
Metal Lubricants Co.—**2056**
Metalwash Machinery Corp.—**1467**
Park Chemical Co.—**406**
Salem-Brosius, Inc.—**241**
Sinclair Refining Co.—**2049**
Socony-Vacuum Oil Co., Inc.—**1546**
Surface Combustion Corp.—**714**
Tenney Engineering, Inc.—**2330**
Tranter Manufacturing, Inc.—**1353**
Webber Mfg. Co., Inc.—**1656**

Supplies, Trays, Refractory Parts

American Brake Shoe Co., Electro-Alloys Div.—**762**
Cambridge Wire Cloth Co.—**1646**
Continental Industrial Engineers, Inc.—**843-G**
Ohio Steel Foundry Co.—**1435**
Park Chemical Co.—**406**
Rolock, Inc.—**1724**
Sentry Co.—**445**

Vacuum Furnaces

Consolidated Vacuum Corp.—**2156**
Continental Industrial Engineers, Inc.—**843-G**
Harper Electric Furnace Corp.—**1919**
National Research Corp.—**1160**
Optical Film Engineering Co.—**1457**
Stokes Machine Co., F. J.—**2167**

Industrial Ovens

American Gas Association—**854 A to F, 843 G to K**
American Gas Furnace Co.—**843-H**
Continental Industrial Engineers, Inc.—**843-G**
Electric Furnace Co.—**636**
Gas Appliance Service Inc.—**854-A**
Harper Electric Furnace Corp.—**1919**
Salem-Brosius, Inc.—**241**
Surface Combustion Corp.—**714**
Westinghouse Electric Corp.—**360**

Temperature Indicators and Fuel Controls

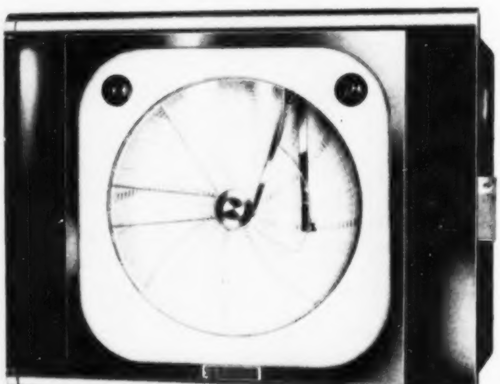
This topic was introduced in *Metal Progress* for October 1952 with a paragraph to the effect that the big news in control instruments was the change from delicate mechanisms (mechanical) to rugged assemblies of electronic tubes. In October of 1953 the article started thus: "Control of the many variables encountered in the operation of industrial furnaces continues to be reined into narrower limits and to become more complete, explicit and instantaneous." That last sentence might now be repeated, since it well states a thread running through much of the information forwarded to the editors by exhibitors at the 1954 National Metal Exposition.

Aside from these considerations, however, the inquiring metallurgist who is charged with the control of production will find that considerable attention is being given to the *simplification* of complicated control systems. A striking instance is the problem of maintaining a neutral furnace atmosphere. If he inquires among the various furnace builders he will find two schools of thought – one holds that if the dew point of an endothermic atmosphere is constant (and proper for the steel being heated at a given temperature), then the metal will be neither carburized nor decarburized. The other school holds that this concept is entirely too simple – that slight variations in CO_2 and H_2 have large influence on the way the atmosphere treats the hot steel.

Surface Combustion Corp. (Dec. '53, p. 101) and Lindberg Engineering Co. (Feb. '54 p. 91) have gone on record as believing that dew-point control is a sufficient though indirect approach to the problem, and base their views on much laboratory experimentation and experience in customers' plants. The endothermic atmosphere generator itself requires flow meters on both raw gas and air inlet, pressure regulators on supply lines and temperature control of the gas cracking unit – at least this much in addition to dew-point and heat treating temperature control – but Lindberg believes that a completely automatic unit is just around the corner. In fact, Ipsen Industries, Inc. will show an "automatic carbon potential controller" for dew point and temperature known at the "Carbotronik" unit (July '54, p. 98). Surface Combustion Corp. calls its equipment for automatic continuous carbon control the "Autocarb".

In this same connection, Illinois Testing Laboratories will show the "Alnor 7000 U Dewpointer", believed to be more accurate and reproducible than equipment depending upon the deposition of moisture on a cool mirror. In the Dewpointer, small samples of gas from the furnace are withdrawn at frequent intervals, compressed, then suddenly expanded past an observation window. If one such sample compressed to P_1 shows fog on expansion, and the next sample a few seconds later compressed to P_2 shows no fog, then the dew point is bracketed

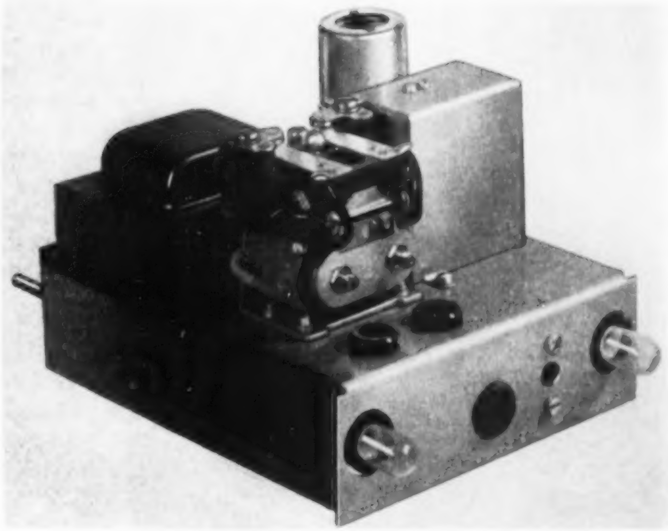
Bristol Co.'s "Dynamaster" Time-Temperature Program Controller



between the two tabular values corresponding to those two pressures.

The Bristol Co. will show an interesting method of establishing any desired heating, soaking and cooling cycle. As shown in the photograph, left, below, a cam is cut in transparent plastic to guide the control needle governing the "Electronic Dynamaster" – really a system of interrelated devices designed for the equipment in question and needed to insure that the workpiece is at the desired temperature at the desired time.

Among a wealth of devices, the Industrial Div. of Minneapolis-Honeywell Regulator Co. shows that there is still opportunity to improve some of the oldest pyrometric equipment. For example, it is often necessary to measure radiation from a small object or a small area of a large object. These miniature "Brown Radiamatic" assemblies are hardly larger than a spool of carpet thread; they contain an improved thermopile which speeds the response fourfold. One model is useful for the range 200 to 2500° F. and responds to temperature changes in 2 sec. The humble thermocouple also has had attention; a butt welded joint gives considerably faster response than the standardized twisted-wire fusion-welded end. "Faster response means better control" says Minneapolis-Honeywell, and will have an operating exhibit to prove it.



"Anticipatory" Time Proportioning Chassis (Plug-In) for New Wheelco Capacitrols

Wheelco Instruments Div. of Barber-Colman Co. will introduce the "400 Series Capacitrols", featuring unit construction and plug-in components which look much like a neatly built radio set. The standardized aluminum case will accommodate any one of several plug-in types of measuring devices (electronic) in its upper compartment, while the lower half will accommodate a plug-in control chassis. One unit can be removed for servicing or replaced by another of somewhat different function without interrupting the functioning of the other member of the team.

Representatives of West Instrument Corp. will also be glad to explain to the visitor (and the visitor will call upon his knowledge of electrical engineering) the way the "Model J. S. Stepless Controller" controls an electric furnace. Outside, it is a neat steel box connected with what appears to be an indicating pyrometer; the indicator, however, contains a beam of light which is the more intense the further the actual temperature is from the set point. Also a photocell whose output (varying with the amount of light it receives) "modulates" the power put into the heating elements in stepless fashion. Modulator, amplifier and reactor are within the neat steel box.

E.E.T.

Classified List of Exhibitors and Booth Numbers

Indicators, Recorders and Controllers

American Gas Association—**854 A to F, 843 G to K**
Bristol Co.—**1441**
General Electric Co.—**1060**
Hones, Inc., Charles A.—**854-E**
Illinois Testing Laboratories—**1154**
Ipsen Industries, Inc.—**819**
Leeds & Northrup Co.—**442**
Lindberg Engineering Co.—**662**
Minneapolis-Honeywell Regulator Co., Industrial Div.—**1347**
Partlow Corp.—**465**
Pyrometer Instrument Co., Inc.—**1120**
Tempil Corp.—**1523**
West Instrument Corp.—**2245**
Wheelco Instruments Div., Barber-Colman Co.—**1219**

Pyrometers

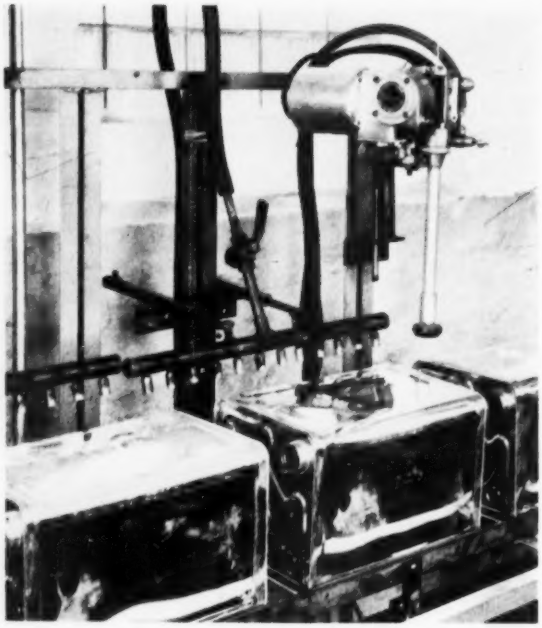
Bristol Co.—**1441**
General Electric Co.—**1060**
Hones, Inc., Charles A.—**854-E**
Illinois Testing Laboratories—**1154**
Leeds & Northrup Co.—**442**
Minneapolis-Honeywell Regulator Co., Industrial Div.—**1347**
Partlow Corp.—**465**
Pyrometer Instrument Co., Inc.—**1120**
West Instrument Corp.—**2245**

Gas Samplers and Analyzers

Cities Service Oil Co.—**1216**
Consolidated Vacuum Corp.—**2156**
Continental Industrial Engineers, Inc.—**843-G**
Flexonics Corp.—**1555**
Illinois Testing Laboratories—**1154**
Ipsen Industries, Inc.—**819**
Leeds & Northrup Co.—**442**
Lindberg Engineering Co.—**662**
Surface Combustion Corp.—**714**

Fluid and Pressure Controls

Bristol Co.—**1441**
Hauck Mfg. Co.—**2124**
Illinois Testing Laboratories—**1154**



Mogul Solder Gun and Preheat Burners Soldering the Side Seam of 5-Gal. Cans, as They Move Under the Gun at a Constant Speed of 60 Ft. per Min.

Welding and Associated Processes

In choosing the subdivisions of this general section, the Editors doubted whether such a topic as thermit welding should be included, not because it is unimportant but because the principal firm promoting it has entered the arc welding business. Thus, Metal & Thermit Corp. at the National Metal Exposition will operate alternating current welding machines and make welds at high speed with newly developed "Murex contact electrodes" whose heavy coatings contain a high percentage of iron powder. (As noted below, Lincoln Electric, Hobart and Westinghouse present versions of this same idea.)

Superposition of magnetic forces on the normal arc has successfully solved some difficult problems and led to some new equipment. For example, "cone-arc welding" (May, '54, p. 194) uses an inert-gas-shielded arc from a tungsten electrode with an "Alnico" permanent magnet nozzle and soft iron tip. Apparently the resultant of the electric and magnetic forces swirls the arc in a tight vortex, which can weld small, thin-walled tubing into a header in a matter of seconds. In this same general category, American Brake Shoe Co. will feature its "M-F Semi-Automatic Magnetic Flux Welder" in a demonstration designed to show its advantages over straight rod welding of mild steel as well as for hard facing.

Magnetic forces are used in another way – primarily for pressure, by Precision Welder & Flexopress Corp. as illustrated on the opposite page. The magnetic forces are obtained directly from the transformer's secondary current, and are varied by changing the wave form of the primary current. Unusually rapid welding of dissimilar and conductive metals is achieved, as well. A new resistance welding head with more accurate pressure and after-heat controls will be displayed by Raytheon Mfg. Co.

Sciaky Bros., Inc., will exhibit the "Type SPT 2 Three-Phase Spot Welder" and demonstrate its adaptability to a wide variety of work on aluminum and other sheet metal. It is especially suitable for repetitive production. For example, handles are now attached to pitchers, 160 per hr., by one man, whereas a previous design of mechanical joint was made at the rate of 50 per man-hour.

Reverting again to arc welding, Lincoln Electric Co. will have its newest electrodes ("Jetweld 1" and "Jetweld 2"), equivalent to the standard E-6012 and E-6020 but capable of operating at 50% increased speed. As the welding current going through a given electrode diameter increases, a limiting point is reached where the excess heat melts too much of the base metal – a condition

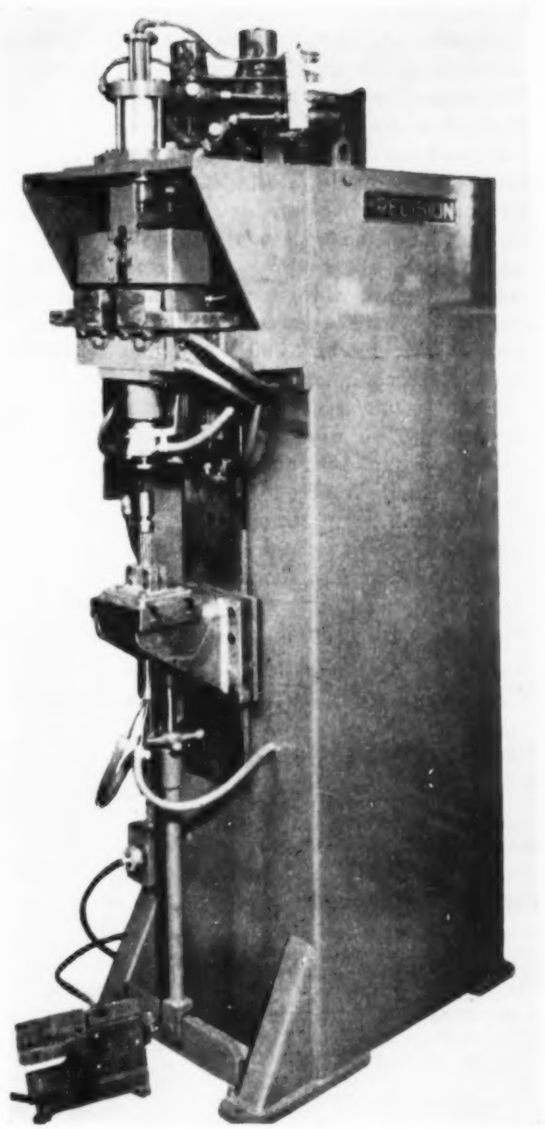
usually indicated by excessive spatter. However, when the coating contains a considerable proportion of powder metal, the surplus heat is used to melt it; thus the rate of deposition (speed of welding) is correspondingly increased. Lincoln will not be alone in showing this innovation; Hobart Brothers Co. will have its "Hobart Rocket Iron Powder Type Coated Electrodes", and Westinghouse has competing electrodes, as well.

Westinghouse Electric Corp. will also operate the new "West-ing-arc process", which broadens the scope of shielded-arc welding with consumable electrode. Westinghouse representatives will demonstrate how this is achieved with a combination of "MS-20" electrode wire, gun, control and wire-driving mechanism. A 500-amp. constant potential machine, self regulating, known as the "RCP-Welder" has been designed for this combination, and is said to perform equally well in either semi-automatic or automatic operations. Miller Electric Mfg. Co. will also have on display new alternating-current arc welders with built-in high-frequency generators, so they are adaptable for either normal metallic-arc welding or tungsten-arc (shielded with inert gas). A water-cooled torch for heavy-duty continuous welding by the inert-gas-shielded method has also been devised by Linde Air Products Co. (unit of Union Carbide & Carbon Corp.).

Ingenious devices for taking some of the profanity out of the operation will be offered by Cam-Lok Division of Empire Products, Inc. (quick disconnect electrode holders); Erico Products, Inc. ("Cadweld Taper-Lok" quick connectors); National Torch Tip Co. (cutting and welding tips of superior durability); Torit Mfg. Co. (a small acetylene-air outfit for brazing or soldering). Oxy-acetylene welding torches of small size, one weighing 6 oz. for sheet metal welding and brazing and another even lighter for lead burning, can be seen in Air Reduction Sales Co.'s display.

Lower and lower temperatures for joining operations bring us through various brazing and soldering operations to the ultimate – "cold welding", whose principles as applied to wrapped wire terminals were discussed in *Metal Progress* for July '53, p. 161. "Koldwelding" tools and methods for lap welding aluminum sheet or foil without heat, electricity or chemicals will be demonstrated by Utica Drop Forge & Tool Corp. Surfaces are merely scratch-brushed prior to joining.

Coming back to the well-known brazing operations, many visitors to the Metal Show will doubtless stop at Ferrotherm Co.'s booth to learn about the newly developed method for furnace brazing of titanium. As pointed out by Ferrotherm's engineers, a ready means for brazing this metal and its alloys will encourage its use in many complicated parts where welding – even though intensively studied (June '54, p. 170) – would not be suitable. The same company will exhibit intricate heat exchangers "Nicrobrazed" of stainless steel (March '54, p. 108) wherein the furnacing is done in a closed retort containing atmosphere strictly limited in such gases as O_2, CO_2, and H_2O, which form enough oxide on the steel to prevent alloying with the filler material. International Nickel Co. will also explain how ductile iron can be welded with "Ni-Rod 55", a 60-40 Ni-Fe electrode, coated (July '54, p. 124).



Magnetic Force Welder to Be Shown by Precision Welder & Flexopress Corp.

Outstanding cost-cutting applications of silver brazing (Dec. '53, p. 161) will be demonstrated by Handy & Harman. Solders of various types will be

displayed by Alpha Metals, Inc. (for stainless steel), and Kester Solder Co. The last-mentioned features "Solderforms" – rings, disks, and stampings of any shape of solder sheet, flux-filled. Soldering operations need not depend upon skilled workmen, as is demonstrated by the illustration on page 102 of the "Solder Gun" made by Metallizing Co. of America. Passage of the 5-gal. cans is from left to right, first under the series of preheating flames and then under the "gun", which feeds solder into the side seam at precisely the correct rate. One operator and one such machine make 60 ft. per min. with half the solder used in a hand or dipping operation.

Before leaving the subject of welding, mention should be made of oxy-acetylene cutting, which has solved so many difficult production and salvage problems. Linde Air Products Co. discovered some years ago that the oxygen lance could substitute for a rock drill, and now has a lance head which feeds metallic powders into the oxygen stream to give extra heat and fluxing action when brick or other nonmetallics are struck in salamanders, and other tough nuts to crack. Heath Engineering Co. will have a newly designed "Model 500 Ultra-Graph" in operation for precisely guiding the oxy-acetylene flame around intricate templets. Arcair Co. combines compressed air and an electric arc into a torch for gouging out weld or casting defects.

Mechanical fasteners are still vigorous competitors for attention by those who have difficult joints to make. Elastic Stop Nut Corp. of America has paid particular attention to designing lock nuts for the aircraft industry. A modern fighter may have as many as 75,000 such fasteners in its airframe, and a saving of 1.5 lb. per 100 by correct design therefore totals nearly half a ton. Tinnerman Products, Inc., has a new line of self-anchoring "Speed Grip Nut Retainers" which require no special tools nor skills. Or if you must join two sheets of metal where the inside is inaccessable to a bucker-up, just get Du Pont Industrial Rivets, insert them from the outside, warm the end with an electric soldering iron, and a tiny bit of explosive in the axis of the shank goes pop and expands it tightly in the hole.

Classified List of Welding Exhibitors and Booth Numbers

Flame Welding Equipment and Supplies

Air Reduction Sales Co.—**341**
Linde Air Products Co.—**653**
National Torch Tip Co.—**2048**

Resistance Welding

Bridgeport Brass Co.—**1015**
Electric Arc., Inc.—**2102**
Expert Die & Tool Co., Expert Welding Machine Div.—**1330**
Fansteel Metallurgical Corp.—**1559**
Miller Electric Mfg. Co.—**248**
Precision Welder & Flexopress Corp.—**265**
Raytheon Mfg. Co.—**1739**
Sciaky Bros., Inc.—**435**
WW Alloys Inc., division of Fansteel Metallurgical Corp.—**1559**
Westinghouse Electric Corp.—**360**

Arc Welding and Electrodes

Air Reduction Sales Co.—**341**
American Brake Shoe Co.—**762**
Banner Mfg. Co.—**1019**
Cam-Lok Div., Empire Products, Inc.—**1056**
Electric Arc, Inc.—**2102**
Erico Products, Inc., Caddy Arc Welding Accessory Div.—**1429**
General Electric Co.—**1060**
Harnischfeger Corp.—**120**
Hobart Brothers Co.—**365**
International Nickel Co., Inc.—**745**
K S M Products, Inc.—**1115**
Lincoln Electric Co.—**646**
Linde Air Products Co.—**653**
Metal & Thermit Corp.—**409**
Metallizing Co. of America—**1456**
Miller Electric Mfg. Co.—**248**
National Carbon Co.—**653**
Nelson Stud Welding Div., Gregory Industries, Inc.—**415**
Plastic Metals Div., National Radiator Co.—**1911**
Smith Welding Equipment Corp.—**2250**
Square D Co.—**1437**
Westinghouse Electric Corp.—**360**

Positioners

Aronson Machine Co.—**2354**
Harnischfeger Corp.—**120**

Brazing and Soldering (manual or automatic)

Air Reduction Sales Co.—**341**
Alpha Metals, Inc.—**2344**
American Gas Furnace Co.—**843-H**
Banner Mfg. Co.—**1019**
Continental Industrial Engineers, Inc.—**843-G**
Ferrotherm Co.—**2247**
Gas Appliance Service Inc.—**854-A**
Goldsmith Bros. Smelting & Refining Co.—**2119**
Handy & Harman—**342**
Kemp Mfg. Co., C. M.—**B-854**
Kester Solder Co.—**1548**
Lindberg Engineering Co.—**662**
Linde Air Products Co.—**653**
Metallizing Co. of America—**1456**
Smith Welding Equipment Corp.—**2250**
Torit Mfg. Co.—**2350**
Uniworld Research Corp. of America—**126**
Weltronic Induction Heating Corp.—**163**

Thermit Welding

Erico Products, Inc., Caddy Arc Welding Accessory Div.—**1429**
Metal & Thermit Corp.—**409**

Gas and Arc Cutting

Acetogen Gas Co.—**2147**
Air Reduction Sales Co.—**341**
Arcair Co.—**1445**
Heath Engineering Co.—**2340**
Linde Air Products Co.—**653**
National Torch Tip Co.—**2048**
Plastic Metals Div., National Radiator Co.—**1911**
Smith Welding Equipment Corp.—**2250**

Cold Welding

Utica Drop Forge and Tool Corp.—**233**

Fasteners

Acme Steel Co.—**2129**
Chicago Rivet & Machine Co.—**1623**
Chicago Screw Co.—**2223**
Du Pont de Nemours & Co., E. I.—**2050**
Elastic Stop Nut Corp. of America—**2023**
Goodrich Co., B. F.—**1650**
Heli-Coil Corp.—**1655**
KSM Products Inc.—**1115**
Nelson Stud Welding Div., Gregory Industries, Inc.—**415**
Southco Div., South Chester Corp.—**2324**
Steel Sales Corp.—**725**
Stimpson Co., Inc., Edwin B.—**1701**
Tinnerman Products, Inc.—**1208**
Waldes Kohinoor, Inc.—**1556**

E. I. du Pont de Nemours & Co. will demonstrate the safety of this device in its exhibit booth.

B. F. Goodrich Co. will exhibit its "Rivnut" which has to be seen to be believed – a one-piece blind fastener with internal threads which serves as a rivet, a nut plate, or both! Heli-Coil Corp. is promoting the use of thread inserts (July '54, p. 125) and tools for their installation. A thread insert is a wire helix; the cross section of the wire is triangular so the closely wound helix forms the same inner shape as a tapped hole. The inserts can be hard and thus are adapted to parts of soft metal. Or they may be of nongalling material for joints which must be frequently disassembled. E.E.T.

Cleaning and Finishing

INNUMERABLE and perhaps often duplicated as the equipment and supplies for cleaning and finishing may seem to the uninitiated, to the man concerned with these activities this profusion of available materials increases the possibility that he will find the more nearly specific answer to his unique problem. The preparation of metal surfaces for subsequent finishing processes involves methods that can be grouped under four broad classifications, the most common of these being mechanical surface preparation and chemical cleaning. Equipment and supplies for these two methods, as well as for the third, ultrasonic cleaning, will be displayed and described at the Metal Show.

Mechanical Surface Preparation – Grinding, polishing, blast cleaning, brushing and buffing belong in this category.

Production Machine Co. will have three machines for centerless grinding and finishing. Type 484-W, which will be shown for the first time, uses waterproof belts and standard coolants for light grinding on cylindrical work up to 1½ in. diameter. Grind and finish cuts can be made without rehandling the work. Shown also will be Type 101-W which handles work up to 6 in. diameter and can reverse feeds automatically. A recent addition to the machines built by Hammond Machinery Builders, Inc. is a rotary, automatic, indexing polishing and buffing machine. This model accommodates up to six head and stand units, operates on a high-speed index movement and has an adjustable dwell period. The table has seven work spindles, six of which support and rotate the work at the wheel station; the remaining spindle is at the operator's station in front of the machine for loading and unloading. Visitors seeking information on brushing machines and the wide variety of power brushes that are needed for special finishing operations will find it at the booth of the Osborn Mfg. Co.

Another commonly used method of mechanical surface preparation is blast cleaning (June 1954, p. 104). Equipment for this work will be displayed by Vacu-Blast Co., Inc., American Wheelabrator and Equipment Corp., Pangborn Corp., and Clementina Ltd. The latter will also show its latest product, a remote-control valve for all types of sandblasting machines. It is of the deadman type of control – blasting stops when the valve is released. A bleed-off valve opens to release the pressure in the system when the valve is released and, simultaneously, the air intake valve is closed. This unit can be used with all types of abrasives.

Ultrasonic Cleaning – An ultrasonic degreaser will be operated by the Phillips Mfg. Co. to demonstrate the advantage of the larger sonic area resulting from the use of multiple transducers. Detrex Corp. will also exhibit an ultrasonic cleaning machine as well as its new rotary-gyro degreaser for solvent vapor cleaning. The gyro movement of the work baskets is likened to a ferris wheel, except that the work baskets also revolve during this movement and make five revolutions to each cycle of the gyro conveyer. This combination of movements is said to increase cleaning efficiency.

Chemical Cleaning – Other Detrex cleaning aids to be described to show visitors for the first time are a group of phosphoric acid-type cleaners called the 800 series, and the prephosphating metal cleaner 771 Paintbond. Parker Rust Proof Co. will have acid, alkali, emulsion and solvent-type cleaning compounds at its booth. (The solvent, alkaline and emulsion cleaning of steel was described in *Metal Progress* for April 1954, p. 230.)

A compact unit that is well suited for shops having small production, or in large plants where it will eliminate the need for carrying small parts to a central degreaser, is the Baronet barrel degreaser made by Baron Industries. A 55-gal. galvanized drum is used as the degreasing chamber. This is equipped with a pump and spray lance

for flushing the parts with trichlorethylene vapors. The Diversey Corp. will describe its pickling, cleaning and degreasing preparations, including heavy-duty cleaner No. 909 which is suitable for ferrous and nonferrous metals and alloys, and its aluminum deoxidizer and smut remover No. 514.

Substantial savings in acid consumption and increased cleaning efficiency can be obtained with pickling inhibitors that are stable in boiling acids, readily soluble and prevent pitting and smut formations on the steel. E. F. Houghton & Co. has compounded an inhibitor, Acitrol 3129, for use in hydrochloric, sulphuric or phosphoric acids which is reported to have all of the aforementioned characteristics; more information will be available at the booth. The American Chemical Paint Co. will describe its Rodine liquid and solid inhibitors for acid pickling baths.

Protective Coatings – If all metals could withstand the ravages of corrosion and oxidation as well as has the 16-centuries-old iron pillar at Delhi (still older – 2200 years – but less known is the Asoka iron column, also in India), there would be little need for protective coatings. Since coatings must be used, they should be the kind best suited for the application, as, for example, the American Chemical Paint Co. colorless coatings Alodine No. 1000 and No. 1200. These are chromate types (May 1954, p. 122) to improve paint adherence and corrosion resistance of fabricated products for outdoor exposure. A number of recently developed finishes will be revealed by Parker Rust Proof Co. for aluminum, iron and steel. "Pre Namel" 420 is a pretreatment for aluminum prior to porcelain enameling; "Bonderite" 710 and 720 are to impart corrosion resistance to aluminum; "Parcolacs" 101, 102 and 103 are black, aluminum and olive-drab corrosion resistant finishes for iron and steel.

Table-Type Airless Blast Cleaning Machine to Be Operated at the Metal Show Is This 72-In. Wheelabrator Swing Table Made by American Wheelabrator & Equipment Corp. Distinctive features of the machine are the table mounted on the door and the elimination of a pit for the abrasive hopper.

If you are looking for "pushbutton" rust prevention, E. F. Houghton & Co. has it in a 12-oz. pressurized can, similar to the Aerosol insecticide dispensers. The spray dries on the surface of the metal to be protected – tools, dies, gages, hardware and similar items – into a thin transparent film. Called "Rust Veto Spray", the contents of one can will cover about 80 sq.ft. Another new coating applied by spraying is "White Vincote", a white pigmented vinyl coating for protection of interiors of paint spray booths. The coating dries quickly into a tough film which can be peeled off easily.

Related Finishing Items – "Platecoils", formerly available in carbon steel, Type 316 stainless and Monel, are now being made of Carpenter 20 stainless and Hastelloy B and C alloys for use in highly corrosive solutions such as acid pickling baths. These embossed metal sheets through which heating medium is circulated to heat tanks of solution are reported to have a high transfer of heat and half the weight of equivalent length in pipe coil. They are made by Tranter Mfg., Inc. Heil Process Equipment Corp. will feature ventilating systems for corrosive fumes and corrosion-proof exhaust blowers. The ventilating units – hoods, ducts, stacks, and fittings – are made of "Rigidon", a glass-reinforced polyester plastic material.

Greater flexibility of the No. 2 Ransburg process will be demonstrated by Ransburg Electro-Coating Corp. with the painting of a variety of products ranging in size from refrigerators to automobile window moldings. A new sound-color movie will show the process operating in a number of plants. Parts formed by the Chem-Mill process, developed jointly by North American Aviation, Inc. and Turco Products, Inc. will be displayed at the Turco booth. In this process (described in detail on p. 141 of this issue), chemical solutions are used to etch the metal – at present aluminum alloy sheets and forging stock – to any desired contour and to very low tolerances.

Metal spraying, or metallizing as it is often called, has proved its worth as a protective measure against corrosion in countless applications (November 1953, p. 161). The Mogulectric metallizing gun to be shown by the Metallizing Co. of America is said to give foolproof performance which will insure the deposition of coatings of uniform thickness. The gun, designed for stationary operation on large work such as spraying in tanks and on structural steel, has only ten moving members (exclusive of the constant speed motors), only four controls, and a constant wire feed that will not fail. J.P.

Classified List of Finishing Exhibitors and Booth Numbers

Blast Cleaning

American Wheelabrator & Equipment Corp.—**632**
Clementina Limited—**1002**
Pangborn Corp.—**426**
Vacu-Blast Co., Inc.—**1450**

Pickling, Cleaning, Degreasing

Ajem Laboratories, Inc.—**1145**
American Chemical Paint Co.—**1036**
American Cyanamid Co.—**132**
Baron Industries—**2364**
Blakeslee & Co., G. S.—**1016**
Branson Ultrasonic Co.—**2244**
Centri-Spray Corp.—**1745**
Circo Equipment Co.—**225**
Continental Industrial Engineers, Inc.—**843-G**
Dean Products, Inc.—**1401**
Detrex Corp.—**1365**
Diversey Corp.—**1718**
Fansteel Metallurgical Corp.—**1559**
Heil Process Equipment Corp.—**2038**
Houghton & Co., E. F.—**1010**
Ipsen Industries, Inc.—**819**
Kolene Corp.—**1518**
Manufacturers Processing Co.—**1421**
Metal Lubricants Co.—**2056**
Metalwash Machinery Corp.—**1467**
National Carbon Co.—**653**
Oakite Products, Inc.—**1601**
Parker Rust Proof Co.—**2039**
Phillips Mfg. Co.—**1319**
Ransohoff, Inc., N.—**215**
Solventol Chemical Products, Inc.—**347**
Tranter Mfg., Inc.—**1353**
Turco Products, Inc.—**2024**
Universal Tumbling Supply Co.—**2253**
WW Alloys Inc., division of Fansteel Metallurgical Corp.—**1559**

Electroplating and Metallizing

Al-Fin Division, Fairchild Engine and Airplane Corp.—**2270**
Baker & Co., Inc.—**1327**
Circo Equipment Co.—**225**
Consolidated Vacuum Corp.—**2156**
Commercial Filters Corp.—**1530**
Continental Industrial Engineers, Inc.—**843-G**
Dean Products, Inc.—**1401**
Heil Process Equipment Corp.—**2038**
Metallizing Co. of America—**1456**
Fansteel Metallurgical Corp.—**1559**
Stokes Machine Co., F. J.—**2167**
Tranter Mfg., Inc.—**1353**
WW Alloys Inc., division of Fansteel Metallurgical Corp.—**1559**

Rust Preventives and Paints

Aldridge Industrial Oils, Inc.—**1424**
American Chemical Paint Co.—**1036**
American Wheelabrator and Equipment Corp.—**632**
Bede Products Corp.—**231**
Binks Mfg. Co.—**420**
Cities Service Oil Co.—**1216**
Dean Products, Inc.—**1401**
Detrex Corp.—**1365**
Gray Co., Inc.—**2145**
Gulf Oil Corp.—**1560**
Heil Process Equipment Corp.—**2038**
Houghton & Co., E. F.—**1010**
Johnson's Wax—**1326**
Kerns, Co., L. R.—**1440**
Metal Lubricants Co.—**2056**
Metalwash Machinery Corp.—**1467**
Oakite Products, Inc.—**1601**
Parker Rust Proof Co.—**2039**
Ransburg Electro-Coating Corp.—**736**
Socony-Vacuum Oil Co., Inc.—**1546**
Turco Products, Inc.—**2024**

Grinding Wheels, Abrasives

Action Diamond Tool Co.—**1135**
A. I. T. Diamond Tool Co.—**1658**
De Sanno & Son, Inc., A. P.—**2139**
Elox Corp. of Michigan—**1612**
Engis Equipment Co.—**1629**
Manhattan Rubber Div.—**1201**
Metal Removal Co.—**235**
National Diamond Laboratory—**1931**
Nicholas Equipment Co.—**2306**
Porter-Cable Machine Co.—**1443**
Production Machine Co.—**210**
Standard Electrical Tool Co.—**1028**

Brushing, Buffing, Polishing

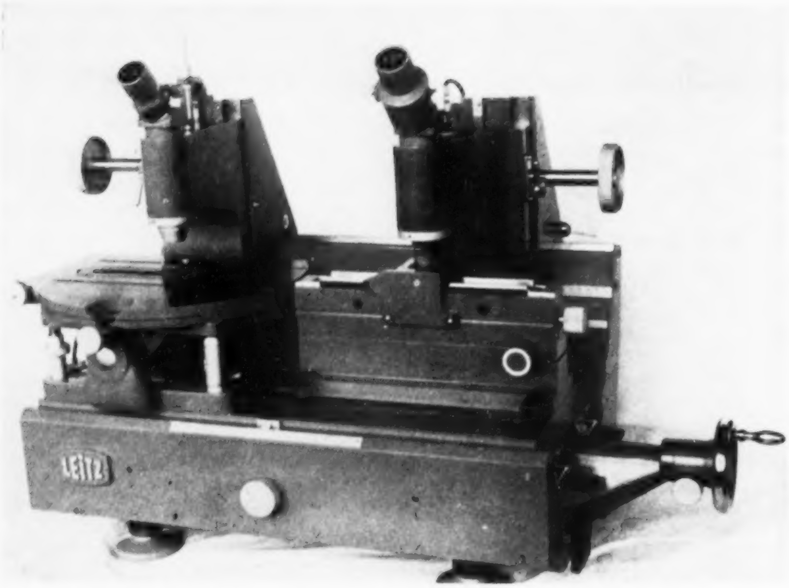
Acme Mfg. Co.—**1640**
Crane Packing Co.—**136**
Hammond Machinery Builders, Inc.—**1142**
Metal Removal Co.—**235**
National Diamond Laboratory—**1931**
Nicholas Equipment Co.—**2306**
Osborn Mfg. Co.—**1320**
Production Machine Co.—**210**
Standard Electrical Tool Co.—**1028**

Instruments

As used here, "instruments" refers to all tools of measurement and control employed in research and production. Not too many years ago the inspection department equipped with a tensile testing machine, or even a hardness tester, was a rarity; such work was done at the main laboratory. Today's control laboratories and inspection stations in the larger plants are equipped with instruments such as X-ray spectrometers, optical comparators, dynamic balancing machines, ultrasonic devices for determining the internal soundness of metals or their thickness, as well as tensile and hardness testers – in fact, the latter are virtually standard equipment.

Speaking of hardness testers, (April, '54, p. 107) even this relatively simple machine has been so adapted to "mass testing" that it is scarcely recognizable as being the kind of machine many of us once used. The Rockwell hardness tester that will be exhibited by the Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., is a fully automatic device that can make between 1000 and 1200 tests per hour. The pieces to be tested, about 2 in. long, are power fed into the tester, automatically placed in position beneath the penetrator, the testing loads are applied and removed and the hardness is indicated on a dial. Tiny photo-electric transistors pick up this hardness indication as impulses that activate relays which classify the tested pieces according to their hardness. The Torsion Balance Co. has a hardness tester ("Kentrall Combination") which can make regular and superficial Rockwell

hardness tests and indicate the results on a dial gage having one numerical scale. All regular (60, 100 and 150-kg.) and superficial loads (15, 30 and 45-kg.) can be used with any standard indenter (C, N or ball-type) on this tester, which will be exhibited.



Highly Accurate Measurement of Internal Dimensions, as in Snap, Ring and Bore Gages, Is Possible to 50 Millionths of an Inch With the Leitz Perflectometer to Be Shown by the George Scherr Co., Inc. This instrument is based on a new measuring principle which projects optically an index line against one side of the part to be measured, which in turn reflects into the eyepiece

The demands of production, and research as well, are for measures that are faster, more accurate and require a minimum of operative skill; the present spectrometers (February '54, p. 87) provide a good example of instruments which meet these requirements. The two types, research and production, to be shown by Baird Associates, Inc., are designed for the respective use; in addition the former has a wider spectral range than earlier models, and has facilities for the use of sheet samples or samples in solution. Improvements that are common to both types in the new models are increased stability through a new optical mount, and simpler and faster operation by means of a redesigned sample compartment and electronic components.

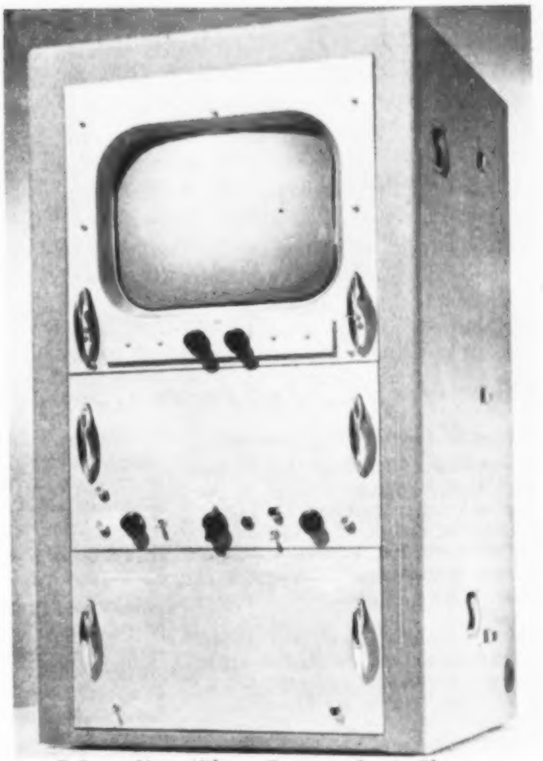
Radiography of Large Structures Poses No Problem Since Portable X-Ray Units Have Become Available. (Courtesy Balteau Electric Corp.)

As long as there are laboratories and new problems to work on, the laboratory personnel will always find it necessary to build special equipment until such special tests as may be needed become standard. An example is creep and stress-rupture testing, not too long ago a special test with equipment either built for it or modified by the laboratory, or custom-built to "nonstandard" specifications. Riehle Testing Machines Div., American Machine and Metals, Inc., will display its 12,000-lb. capacity creep and stress-rupture testing machine (December '53, p. 124) which features a self-aligning method of holding the samples to prevent bending moments, and integral electrical equipment. If your laboratory or production testing requires a machine for tension and compression testing (May '54, p. 168 and 200) in the range of 10 g. to 100 lb., Instron Engineering Corp. will have one to show. It's a small instrument, a so-called "table model", has a crosshead which is driven by magnetic clutches and change gears to provide a choice of constant and reversible speeds over a range of 0.2 to 50 in. per min., and a recording system for stress-strain curves.

Metallurgists were the first to use extensively the technique of X-ray diffraction – now the oil, electronics and building-materials industries have turned to it. In metallurgy it has provided the answer to many of the questions regarding the structure of metals, and how the crystal structures are affected by heat treatment, fatigue, work hardening and other processes. But it is the more mundane application of testing for soundness of metals that has brought the instrument into control laboratories. For example, High Voltage Engineering Corp. will display its portable million-volt machine which employs Van de Graaff voltage generation, a principle formerly applied mainly to stationary equipment used in physics research and cancer treatments. The size of the X-ray source is less than 1 mm. to enable the production of sharp radiographs, and penetration of the beam is up to 4½ in. of steel for an exposure of ½ hr. The equipment requires 2-kva., 220-v., 3-phase, 60-cycle current and does not require any external cooling lines.

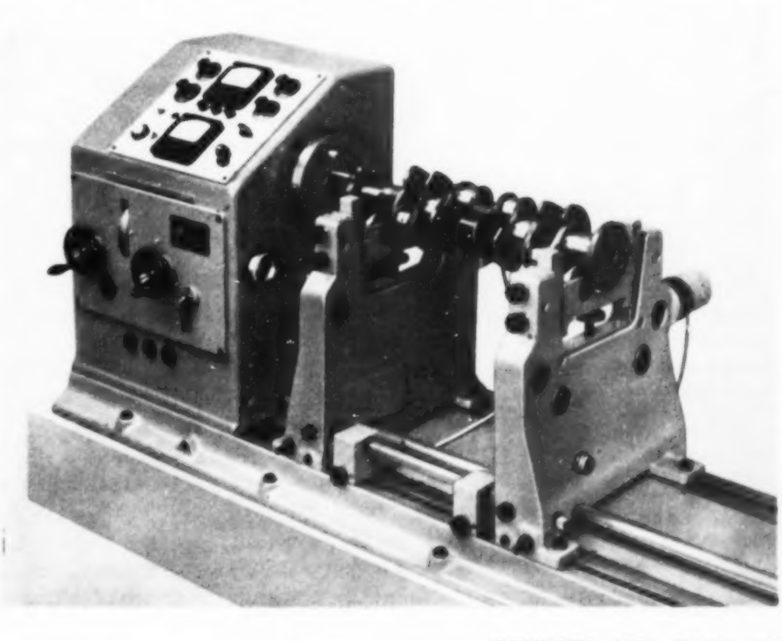
X-ray machines that have been designed to withstand the rough handling which they are likely to receive in factory and field work are to be displayed by Balteau Electric Corp. These are lightweight units; the head of the largest instrument (200 kv.) weighs only 153 lb. "X-Iron 180", made by Mitchell Radiation Products Corp., is another lightweight X-ray machine for industrial, pipe-line and shipyard use. North American Philips Co., Inc. will display radiographic units of 60, 160, and 160-300-kv. ratings.

If your laboratory studies and production control problems are chiefly concerned with compounds and the atomic structure of materials, the instrument for making such identifications is the X-ray diffractometer; if the investigation merely deals with elements, their identification is made with an X-ray spectrograph. The difference in the two instruments is in the way the diffracted rays reach the Geiger counter which measures their intensity. The diffractometer detects and records all rays diffracted from the specimen.



B-Scan Unit (ElectroCircuits, Inc.), Shows a Cross-Sectional View of Flaws in Metals for rapid scanning under production conditions.

Dynamic Balancing Machine to Be Shown by Testing Equipment Co. for Work up to 31½ In. Diameter and 36 In. Long at 600, 1200, 1500 and 3000 Rpm. Balancing is done at resonance by mechanical measurements and electronic evaluation and the amount and location of unbalance is indicated within a 20-sec. test run



the spectrograph separates these diffracted rays by means of an analyzing crystal which resolves and disperses the various wave lengths, much like the optical prism handles visible light in the optical spectrograph. Both of these kinds of instruments will be shown by the North American Philips Co., Inc., and Applied Research Laboratories will demonstrate the advantages of its new X-ray spectrometer with a curved reflecting crystal that increases intensities 10 to 20 times over those of a flat crystal.

Radioactive isotopes (September '53, p. 105), at present one of the more useful products of the atomic pile, are a comparatively inexpensive source of gamma rays for industrial radiography. A camera that can shield 500 curies of cobalt^{60} will be displayed by Atomic Energy of Canada, Ltd. This container for the radioactive source is mounted on wheels for ready mobility and has a simple on-off shutter. Technical Operations, Inc. will exhibit two products for use in gamma radiography, a "Panoramic Exposure Shield" and a "Directional Exposure Shield". The first is an apparatus that has a storage container for the radioactive element and a long tube connected to the container through

Classified List of Instruments Exhibitors and Booth Numbers

Strength-Testing Equipment

Baldwin-Lima-Hamilton Corp.—**1065**
Buehler Ltd.—**1239**
Detroit Testing Machine Co.—**1148**
Ferner Co., Inc., R. Y.—**1247**
Hacker & Co. Inc., William J.—**2310**
Instron Engineering Corp.—**2339**
Olsen Testing Machine Co., Tinius—**1141**
Riehle Testing Machines Div., American Machine and Metals, Inc.—**1248**
Rodgers Hydraulic Inc.—**419**
Steel City Testing Machines, Inc.—**1151**
Testing Equipment Co., Inc.—**2329**

Hardness Testers

American Optical Co.—**2229**
Buehler Ltd.—**1239**
Detroit Testing Machine Co.—**1148**
Ferner Co., Inc., R. Y.—**1247**
Gries Industries, Inc.—**702**
Hacker & Co., Inc., William J.—**2310**
King, Andrew—**1241**
Leitz, Inc., E.—**2224**
Olsen Testing Machine Co., Tinius—**1141**
Riehle Testing Machines Div., American Machine and Metals, Inc.,—**1248**
Scherr Co., Inc., George—**1119**
Service Diamond Tool Co.—**2336**
Steel City Testing Machines, Inc.—**1151**
Testing Equipment Co., Inc.—**2329**
Torsion Balance Co.—**2343**
Uddeholm Co. of America, Inc.—**201**
Wilson Mechanical Instrument Div., American Chain & Cable Co.—**1228**

Gages, Comparators and Associated Devices

Acme Tool Co.—**1005**
Baird Associates, Inc.—**1348**
Branson Instruments, Inc.—**2244**
Brush Electronics Co.—**2317**
Engis Equipment Co.—**1629**
Gaertner Scientific Corp.—**2334**
Industrial Tectonics, Inc.—**2249**
Lufkin Rule Co.—**2311**
Magnaflux Corp.—**1315**
Magnetic Analysis Corp.—**2349**
Micrometrical Mfg. Co.—**2218**
Portage Double Quick Tool Co.—**1535**
Scherr Co., Inc., George—**1119**
Sperry Products, Inc.—**2212**
Starrett Co., L. S.—**2101**
Uddeholm Co. of America, Inc.—**201**

Nondestructive Testing Equipment

Allis-Chalmers Mfg. Co.—**242**
Atomic Energy of Canada, Ltd.—**2040**
American Cystoscope Makers, Inc.—**2323**
Balteau Electric Corp.—**2246**
Branson Instruments, Inc.—**2244**
ElectroCircuits, Inc.—**2136**
General Electric Co., Apparatus Sales Div.—**1060**
General Electric Co., X-ray Dept.—**1042**
High Voltage Engineering Corp.—**1021**
Holger Andreasen, Inc.—**2259**
Industrial X-Ray, Inc.—**2211**
Jarrell-Ash Co.—**1147**
Magnaflux Corp.—**1315**
Magnetic Analysis Corp.—**2349**
Met-L-Chek Co.—**2326**
Mitchell Radiation Products Corp.—**2335**
North American Philips Co., Inc.—**1740**
Sperry Products, Inc.—**2212**
Technical Operations, Inc.—**312**
Turco Products, Inc.—**2024**
Westinghouse Electric Corp.—**360**

Electronic Test Accessories

Baird Associates, Inc.—**1348**
Branson Instruments, Inc.—**2244**
Brush Electronics Co.—**2317**
ElectroCircuits, Inc.—**2136**
Olsen Testing Machine Co., Tinius—**1141**

Microscopes and Attachments

American Optical Co.—**2229**
Bausch & Lomb Optical Co.—**1242**
Buehler Ltd.—**1239**
Engis Equipment Co.—**1629**
Ferner Co., Inc., R. Y.—**1247**
Gaertner Scientific Corp.—**2334**
Hacker & Co., Inc., William J.—**2310**
Jarrell-Ash Co.—**1147**
Leitz Inc., E.—**2224**
Metal Removal Co.—**235**
Reichert Optical Works—**2310**
Scherr Co., Inc., George—**1119**
Uddeholm Co. of America, Inc.—**201**

Analytical Equipment and Supplies

Applied Research Laboratories—**1035**
Baird Associates, Inc.—**1348**
De Sanno & Son, Inc., A. P.—**2139**
Electric Furnace Co.—**636**
Ferner Co., Inc., R. Y.—**1247**
General Electric Co.—**1060**
Jarrell-Ash Co.—**1147**
Laboratory Equipment Corp.—**2316**
Leeds & Northrup Co.—**442**
National Spectrographic Sales Corp.—**2230**
North American Philips Co., Inc.—**1740**
Torsion Balance Co.—**2343**

Scientific Equipment

Baird Associates, Inc.—**1348**
Baker & Co., Inc.—**1327**
Bausch & Lomb Optical Co.—**1242**
Branson Instruments, Inc.—**2244**
Buehler Ltd.—**1239**
De Sanno & Son, Inc., A. P.—**2139**
Diamond Power Specialty Corp.—**2140**
Ferner Co., Inc., R. Y.—**1247**
Gaertner Scientific Corp.—**2334**
General Electric Co., X-ray Dept.—**1042**
Hacker & Co., Inc., William J.—**2310**
High Voltage Engineering Corp.—**1021**
Illinois Testing Laboratories—**1154**
Jarrell-Ash Co.—**1147**
Leeds & Northrup Co.—**442**
Leitz, Inc., E.—**2224**
Lindberg Engineering Co.—**662**
Micrometrical Mfg. Co.—**2218**
National Spectrographic Sales Corp.—**2230**
Optical Film Engineering Co.—**1457**
Stanat Mfg. Co.—**1659**
Steel City Testing Machines, Inc.—**1151**
Testing Equipment Co., Inc.—**2329**
Torsion Balance Co.—**2343**

which the element is moved (after the free end of the tube has been positioned for the exposures) by means of a control cable that can be operated at a distance from the exposed source. The unit can store safely four curies of cobalt^{60}. The second unit is for directional radiation and is handled like an X-ray head. The unit is equipped with automatic exposure timer and shut-off mechanism. The storage container is for 10 curies of cobalt^{60}.

High-frequency sound, or ultrasonics as it is commonly called, was first used during World War I for under-water signaling and submarine detection equipment; the second World War brought about great improvements in these devices, and shortly after, commercial equipment for ultrasonic testing of internal flaws began to make its appearance. (This method of testing was not "new", however; its earliest uses date back to the days after the first war.) The instruments now available for flaw detection (March '54, p. 161) and thickness measurements (February '54, p. 194) by means of ultrasonics look more like television receivers than quality control tools – as a matter of fact, images of the flaws or thickness are projected for scanning on large-screen TV tubes. The ultrasonic testing instruments made by ElectroCircuits, Inc. produce conventional graph-type pips, commonly referred to as A-scan signals, to indicate the flaws and their distance beneath the surface, as well as B-scan signals – these on the TV tube – which indicate the cross-sectional location of the flaws. By connecting a third unit to the system, the B-scan data can be recorded as a series of cross-sectional views to obtain a plan view (called C-scan) of the specimen. (See photo at top of preceding page.)

Branson Instruments, Inc. will show its "Vidigage" for automatic thickness measurements, detection of laminar flaws, and lack of bond between materials. Thickness of the metal or other material is indicated on the 21-in. screen of a TV tube on which the sweep-width scale can be made as large as 17 in. long, to give accuracies as high as 0.1% for some of the thickness measurements. Thicknesses from 0.012 to 2¼ in. can be read directly, and up to 10 in. by calculation. A feature that is stressed is that the transducer probe can be used on a 100-ft. cable without affecting accuracy of the instrument. Another instrument for measuring thicknesses is the "Magnatest FT-100", made by Magnaflux Corp., which is said to be particularly well suited for use in sheet metal forming industries by virtue of its compactness (it uses a flashlight battery for power) and simple operation by holding the probe against the metal and reading thickness on a dial. J.P.

Industrial Equipment, Supplies

EFFICIENT manufacturing and processing of metals must be a thorough-going proposition, with equal attention devoted to what may appear trifling details at first glance as compared to the major machine elements of a processing line. Too often the kinks developing in some insignificant accessory may spell the difference between smooth and bug-ridden operations. It may be the lack of an essential material handling device, or perhaps inflexibility in a drive motor, or failure to provide any of a dozen or more supply items which must take the blame for troubles and tie-ups in an otherwise carefully planned sequence.

So, the wise Metal Show visitor will not overlook the "bits and pieces" sections of the exhibit in his haste to take in as much as possible in a short time. They are many in number and more important than a cursory glance would indicate.

In respect to materials handling alone, the "tremendous trifles" on display are seemingly without end. Conveyers, lifting devices, hand and powered trucks, rollover and turning mechanisms – they are all parts of the mechanical brains which are being perfected to speed and facilitate movement and transfer of parts through succeeding phases of processing.

The automobile industry has understandably taken the lead in adapting new ideas in material movement. That is partly because of the high volume of production to be handled, and partly because of the continuous search for ways to cut a fraction of a cent off unit costs. Automation is the term coming into general use to describe this amalgamation of the production sequence. It is intimately associated with effective materials handling and is finding acceptance in industries widely dissociated from conventional types of metalworking – notably atomic energy and electronics equipment manufacture (March '54, p. 81). There will be striking examples of automation to be found on every hand at the Metal Show, by no means all of them expressly beamed at the mass-production plants.

Electric motors are basic power sources and the increasing complexity of the machines and equip-

ment they must drive has brought along greatly improved flexibility in motor speeds, methods of mounting and general drive arrangements. U.S. Electrical Motors, Inc., is going to demonstrate its improved pneumatic motor control which may be operated either manually or automatically, in the latter case the "signal" being any one of a number of variables such as pressure, temperature, liquid level or proportional flow.

Enclosed-type motors, designed to provide more horsepower in less space and now built to revised N.E.M.A. mounting dimensions, will be displayed by Sterling Electric Motors, Inc., along with many examples of how these motors have been fitted successfully to difficult drive jobs.

Fractional-horsepower variable-speed drives and a new auto-pneumatic control with linear output speeds for automatically controlling temperature, liquid level, pressure and proportional flow head the list of products to be featured by Reeves Pulley Co.

In visualizing the over-all layout of a manufacturing plant, three-dimensional scale models of machinery and equipment are finding increasing favor because they provide a clear picture of just how the operation will look full size. Knight Models, Inc., has developed a full complement of such scale models, ¼ in. to the ft., made of light-weight plastic and incorporating permanent magnets which allow them to be positioned accurately, at the same time permitting quick changes to different proposed locations. They include not only equipment items, but also architectural details such as loading docks, walls and craneways.

For many engineers and nontechnically trained executives, models or perspective drawings are much more readily understood than blueprints or plan views. To aid in their preparation, Charles Bruning Co. is introducing a five-piece templet set, providing a uniform and positive system for determining the dimensions of lines and angles in pictorial drawing without requiring involved projections, calculations, graphs or special boards. They help the draftsman to draw views of an object from any angle, in a fraction of the time it takes to make a plan layout.

Pinpointing a few other profitable stops where industrial equipment and supplies will be on tap: Prefabricated, expandable storage racks for bar, rod and pipe stock which require no tools or fittings to assemble – Jarke Mfg. Co. . . . An engraving machine which will make 15 different sizes of engravings on metal from one master templet – New Hermes Engraving Machine Corp. . . . A fast and accurate cutting and skiving machine for wire braid hose used in hydraulic systems – Weatherhead Co. . . . Triple-stack retaining ring dispenser and applicator – Waldes Kohinoor, Inc. . . . Heavy-duty concrete floor topping of iron, specifically designed for plant floors subject to heavy impact, steel wheel abrasion and heavy loads – Master Builders Co. . . . Automatic dispensing machine which delivers any two preset lengths of gummed tape, moistened for immediate application to shipping cartons – Marsh Stencil Machine Co. . . . Drop-forged drum lifter hooks attachable to chain slings and permitting four steel drums with combined weight of 2000 lb. to be lifted simultaneously – Merrill Bros. . . . Heat-reflecting "aluminized" fabric for safety clothing for use where operators work in proximity to hot metal – Safety Clothing & Equipment Co.

A.H.A.

Classified List of Exhibitors and Booth Numbers

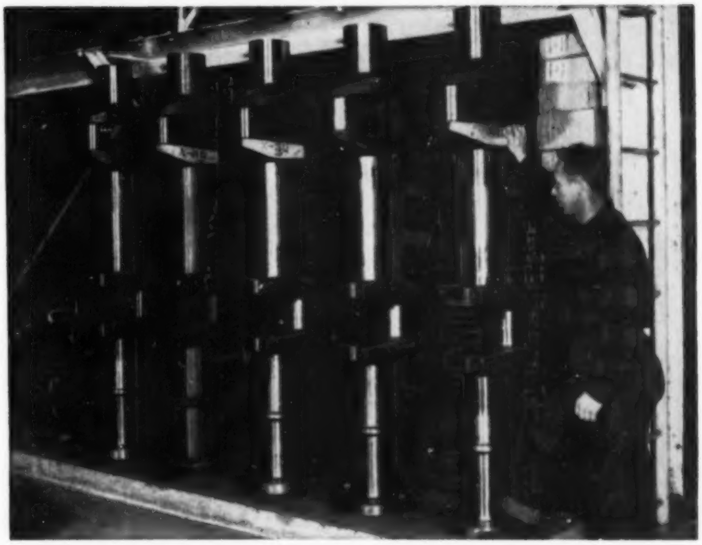
Miscellaneous Mill Supplies and Equipment

Ajusto Equipment Co.—**1057**
Allis-Chalmers Mfg. Co.—**242**
Baker & Co., Inc.—**1327**
Binks Mfg. Co.—**420**
Bruning Company, Inc., Charles—**1128**
Chicago Screw Co.—**2223**
Commercial Filters Corp.—**1530**
Crane Packing Company—**136**
Dean Products, Inc.—**1401**
Diamond Power Specialty Corp.—**2140**
East Shore Machine Products Co.—**1448**
Expert Die & Tool Co., Expert Automation Machine Div.—**1330**
Fawick Airflex Div., Federal Fawick Corp.—**1567**
Flexonics Corp.—**1555**
Gray Co., Inc.—**2145**
Haveg Corp.—**1725**
Industrial Tectonics, Inc.—**2249**
Jiffy Tool Supply Co., Inc.—**1543**
Knight Models, Inc.—**2150**
Manco Mfg. Co.—**1522**
Marsh Stencil Machine Co.—**2015**
Martindale Electric Co.—**1415**
Master Builders Co.—**1618**
Metallizing Co. of America—**1456**
New Hermes Engraving Machine Corp.—**1935**
Reeves Pulley Co., Inc.—**1750**
Renite Co.—**2345**
Safety Clothing and Equipment Co.—**1547**
Salem-Brosius, Inc.—**241**
Schrader's Son Div., A.—**1127**
Spencer Turbine Co.—**843-K**
Stanat Mfg. Co.—**1659**
Sterling Electric Motors, Inc.—**1446**
Texas Co.—**1529**
Torit Mfg. Co.—**2350**
Tranter Mfg., Inc.—**1353**
U. S. Electrical Motors Inc.—**2012**
United States Plywood Corp.—**2240**
Vickers Electric Div., Vickers, Inc.—**1642**
Waldes Kohinoor, Inc.—**1556**
Weatherhead Co.—**2046**

Materials Handling

Allis-Chalmers Mfg. Co.—**242**
Ashworth Brothers, Inc.—**1723**
Brainard Steel Div., Sharon Steel Corp.—**1758**
Cambridge Wire Cloth Co.—**1646**
Dings Magnetic Seperator Co.—**1316**
East Shore Machine Products Co.—**1448**
Electric Furnace Co.—**636**
Expert Die & Tool Co.—**1330**
Jarke Mfg. Co.—**101**
Jomac, Inc.—**2149**
Marsh Stencil Machine Co.—**2015**
Merrill Bros.—**1517**
Michigan Crane and Conveyor Co.—**1943**
Nelson Stud Welding Div., Gregory Industries, Inc.—**415**
Salem-Brosius, Inc.—**241**
Spencer Turbine Co.—**843-K**

Ductile Iron Crankshafts cast at The Cooper-Bessemer Corporation's Mount Vernon, Ohio, foundry and machined at its plant in Grove City, Pa., for GMX-4 engines. The first of this model equipped with a ductile iron shaft was shipped in June, 1953. Cooper-Bessemer initiated development work on high test irons for crankshafts in 1935. Some mechanical properties of ductile iron, compared with those of forged steel . . . traditionally used for crankshafts . . . are shown below.



HIGH
Mechanical Properties, Wear Resistance and Castability make

Comparative Properties

	Ductile Iron	Forged Steel
Tensile Strength	79,200 psi	80,100 psi.
Endurance Limit (Smooth bar)	31,500 "	35,000 "
Endurance Limit (Notched bar)	20,750 "	17,800 "
Modulus of Elasticity	22,600,000	29,000,000
Brinell Hardness	220	170

Ductile Iron an Ideal Crankshaft Material

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Wouldn't your costs tumble for every unit with bearings cored out, counter-weights molded on, and the entire piece cast within tolerances that reduce machining to a minimum?

And wouldn't the excellent castability, toughness, stiffness and machinability of ductile iron bring you advantages like those brought to Cooper-Bessemer?

Glance at the tabulation. You'll see a few reasons why Cooper-Bessemer concluded that ductile iron provides the best combination of properties offered by any material they have tested for crankshafts.

The damping capacity of ductile iron is excellent . . . less than that of gray iron, but far superior to steel. Especially valuable in crankshafts is the relatively high "notched endurance limit" of ductile iron. And another outstanding property is its resistance to mechanical wear... under lubricated or non-lubricated conditions.

Combining the *process advantages* of cast iron and the *product advantages* of cast steel, ductile iron has, actually, many applications.

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing ductile iron under patent licenses. Request a list of available publications on ductile iron . . . mail the coupon now.

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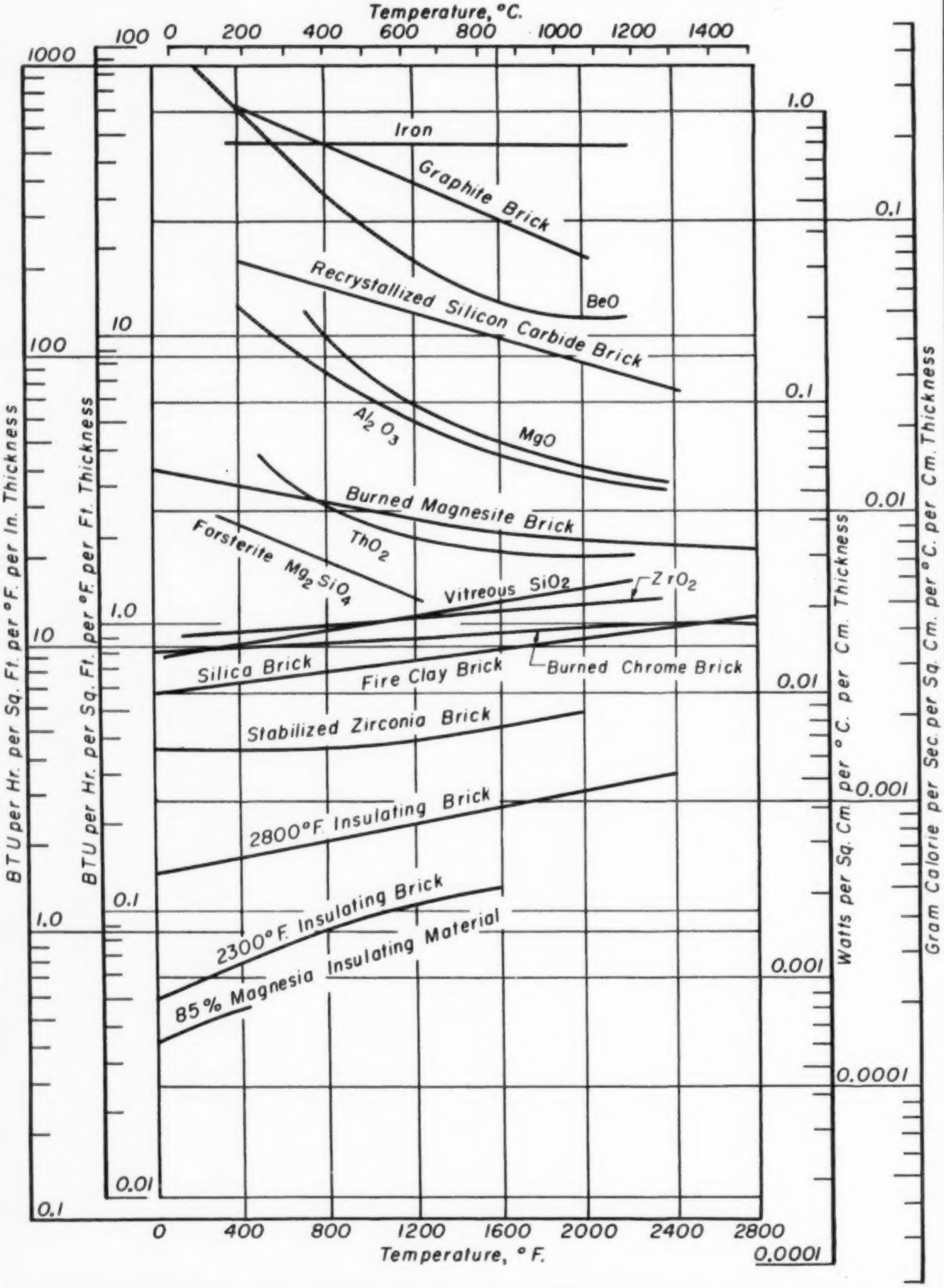
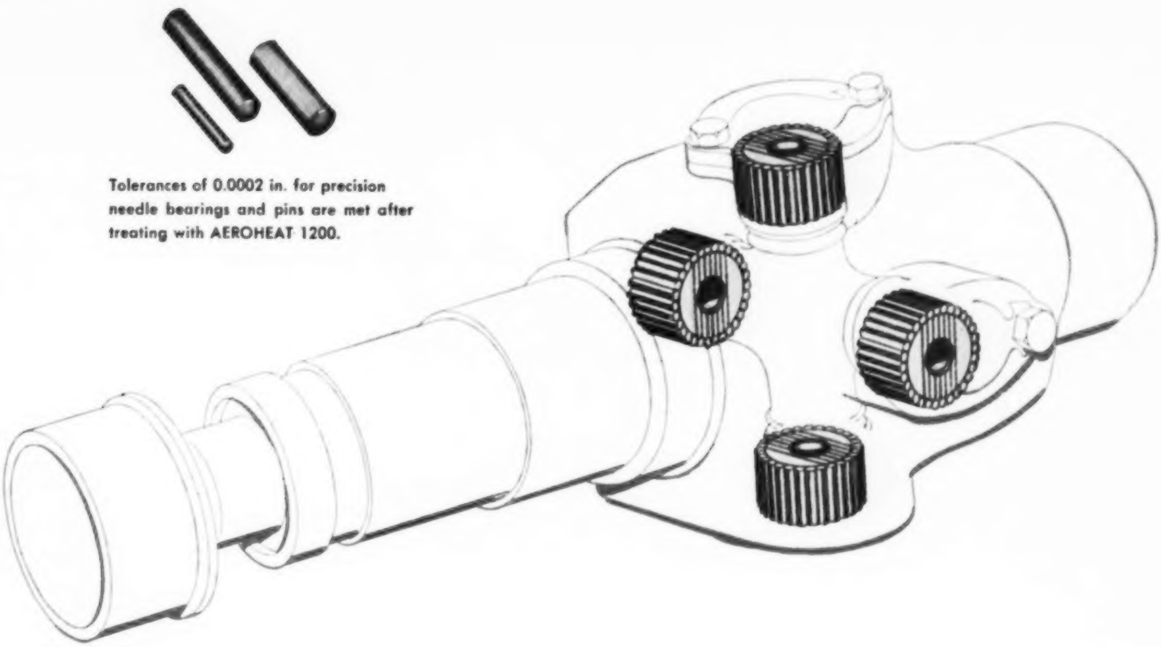
Thermal Conductivity of Common Refractories

Courtesy Battelle Memorial Institute

Mean values presented in the four most prevalent units of measurement. Curves for the oxides are for typical commercial bodies of 5 to 15% porosity.





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Critical Points . . .

BY THE EDITOR . . .

Vacuum Melting— Semicontinuously

SOME YEARS ago, the Editor gave a talk before several chapters to the title "What Makes Metal so Weak?" – a topic designed to intrigue an expectant audience, but simply a general discussion of the concept (then rather new to practicing metallurgists) that the strength of metal depends largely on the discontinuities and dislocations – "holes" is a one-cent word – within the metallic crystal. Another enemy to superior performance in severe service is non-metallic inclusions, especially when, as is their habit, they accumulate between adjoining crystals as they solidify from the melt. Many details of advanced steelmaking practice have been adopted to control the nature and minimize the number of these inclusions even to melting in vacuum to prevent contamination by the ordinary atmospheric gases, either as solutions or as compounds with the metals.

Thus, vacuum melting is by no means new, but until recently it has been confined principally to electrical and magnetic alloys. An important impetus to more widespread use within the last decade has been the release of information from the Atomic Energy Commission about the methods used for securing *very* high vacuums in the *very* large equipment required for separating the explosive uranium isotope from its stable twin by the electromagnetic process. Enough metallurgical work has already been done to indicate that vacuum-melted metals will have so much lower inclusion counts that ball bearings made of them, for example, have notably longer fatigue life. Generally, vacuum-melted metals also have superior stress-rupture characteristics and higher ductility.

Considerations such as these caused Universal-Cyclops Steel Corp. to plan a broad program at Bridgeville (Pa.) works for the improvement of their specialties – toolsteels, stainless steels, and high-temperature alloys. As pointed out by James D. Nisbet, Universal's director of research and development, these materials are expensive, and any improvement in the serviceability of parts made therefrom would be doubly acceptable. Especially is this true in the relatively new field of superalloys, those complex formulations used for gas turbine disks, buckets and blades.

After about a year of planning and building, first heats were cast at Bridgeville early in August in equipment having several unique features. Principal among these, from a commercial standpoint, is that the vacuum does not have to be broken and the furnace opened after every heat. It is in fact a melting machine with several unique features. A fixed tank, some 8 ft. in diameter, 13 ft. high, contains a high-frequency

furnace, and six 1000-lb. ingot molds set in a circle on the tank's base – which is movable, as will appear. In the tank-top, directly above the crucible, is a lock leading to an upper chamber large and high enough for a complete charge of raw materials above a dangling string of additions in proper sequence for the charge of metal being refined.

In brief, this is the way it operates: The third shift opens the tank, removes the ingots already cast, makes minor repairs, fills the furnace with its first charge for the next day, places the charge for the second heat plus additions for the first in the upper charging chamber, closes all openings, and starts the vacuum pumps. By the time the first shift arrives in the morning, the entire apparatus is at low pressure, so melting can start.

Charge materials – metals mostly – must obviously be as free from dirt, oxidized surface, or moisture as possible, so the vacuum pumps can draw off any occluded gas. When melted, dry hydrogen is passed through the furnace to reduce any oxide in the melt; progress of the refining is watched by continuous pyrometer readings and mass spectrograph analyses of the pumped-out gas. At the proper time the lock between tank and evacuated charge chamber is opened and the required additions lowered, one after another, such as carbon, vanadium, aluminum, titanium. The metal is then ready to pour into a mold directly below.

After the ingot is cast the bottom of the tank is turned so the freshly filled mold is directly under a water-cooled tungsten electrode; this keeps the top hot and feeds shrinkage. A water-cooled stool and mold of proper wall thickness, as well as energy from the electrode, control the solidification rate so any dissolved hydrogen may be pumped off continuously and at the end of the 2-hr. solidification cycle only as much gas remains as demanded by solid solubility at near-atmospheric temperature.

This whole cycle is repeated six times in two shifts, and the vacuum is unbroken until the third shift, when the tank bottom is lowered and the six 1000-lb. ingots removed. Such a robot should require little more electrical energy than any induction furnace. Labor saving might counterbalance the cost of the hydrogen gas. At any rate, the expected high quality of difficult alloys can be made in unexpectedly high quantities. All in a vacuum tank.

Come, let us dream a little, and imagine what could be done with a really big vacuum tank, or one containing inert atmosphere. Could it not be big enough to hold a continuous sheet mill – practically a robot already–which would deliver a product requiring none of those mile-long pickling lines?

A Problem in Nomenclature

Recently the Editor of *Metal Progress* and the chairman of one of the ⊕ Handbook subcommittees more or less simultaneously faced the problem of what to call those relatively new cast irons of restricted composition ranges, inoculated with magnesium, cerium, the rare earths, and maybe some other active metals. Nomenclature, both practical and literary, is still quite uncertain. Nearly all American production of magnesium-treated ("inoculated") cast iron is under International Nickel Co.'s license, and that firm uses the term "ductile iron" to describe the product (although it is not registered as a trade mark) in its literature and correspondence. However, it is not as precise or exclusive as might be desired. For example, "ingot iron" is quite ductile; malleable iron can fairly be called ductile in comparison with gray cast iron; some "ductile iron" has very little extension in a tensile test (ductility).

An alternative term widely used among foundrymen in the United States, Canada and England is "nodular iron". Some object to this because it refers to a metallographic appearance, not understandable to everyone, and only apparent in a polished and magnified surface. Another objection is that blackheart malleable cast iron contains small blobs (nodules) of "temper carbon" – roughly equiaxed, spongy aggregates made up of fine flakes of graphite with iron inclusions. On the other hand, most if not all of the graphite in these new cast irons is in well-developed spheres with smooth surfaces; they are crystalline masses which have grown radially from the center. This is a true spherulite (a term long used in mineralogy and lithology) and so would favor the term "spherulitic graphite iron", (abbreviated to "S. G. iron" by Mond Nickel Co., the British counterpart of International Nickel Co.).

Spherulitic graphite iron would therefore seem to be at once precise, distinctive and free from ambiguity. But it certainly is a mouthful, and consequently it is doubtful whether it will ever become very popular, except perhaps in the technical or scientific literature. ⊕

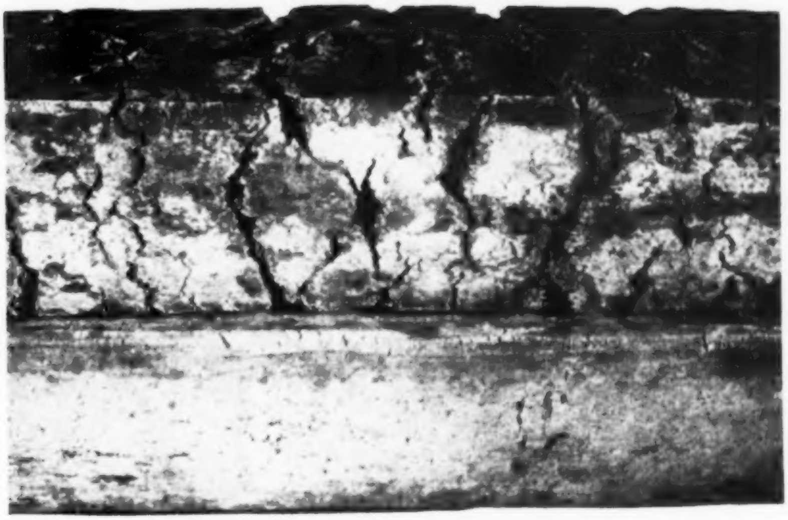


Fig. 1 – Two 5-In. Billets of High-Copper Stainless Steel ("Carpenter 20"), the Top One Extremely Hot Short and Worthless, the Bottom One With Endurable Corner Cracks Which Can Be Machined or Ground Out

Rare Earths in Stainless Steels

*By HOWARD O. BEAVER**

While rare-earth oxides and misch metal are useful degasifiers in complex and high-chromium-nickel austenitic steels, residuals from misch metal are necessary to correct brittleness at forging ranges. The authors have found no detrimental effects to other physical properties.

I WOULD LIKE to say at the start that this paper relates to a field where "confusion reigns supreme". Much has been gossiped and written about the merits and demerits of rare-earth additions to stainless steels – and, as a matter of fact, to many other grades of steel, carbon and alloy. Despite the keen interest and the widespread studies there is still much to be learned about their correct use and the mechanism of their action. The best we can hope to do is to clarify the situation concerning stainless steels, and we will confine our remarks to this group because we have had most of our experience with them. This is not to infer, by any means, that no worth-while applications have been developed for rare earths in alloy steels, cast iron, magnesium and perhaps other nonferrous alloys.

Most of the work at Carpenter Steel Co. has been directed toward improving the hot workability of those stainless types which were not formerly "hot workable" in a commercial sense,

*Metallurgical Department, The Carpenter Steel Co., Reading, Pa. A paper read before an ⊛ regional meeting at Penn State College.

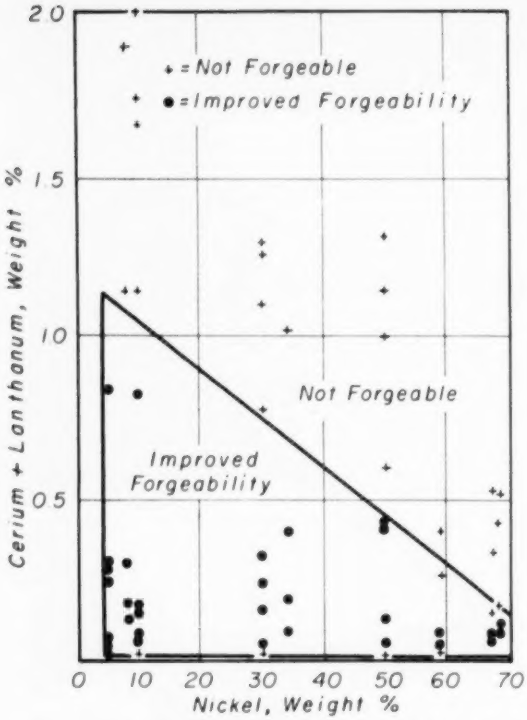


Fig. 2 – Residual Rare-Earth Metal (Principally Cerium and Lanthanum) Will Improve Hot Workability of Austenitic Chromium-Nickel Steels Containing Molybdenum or Other Alloys, the Amount Being Inverse to the Nickel Content.

or those such as Type 310 which posed occasional difficulties. An example of a billet with extreme hot shortness is shown in Fig. 1 in contrast with another of same nominal analysis which was tolerable. The billets shown are for an austenitic analysis developed some years ago ("Carpenter 20", containing 20 Cr, 29 Ni, 1 Si, 2 Mo, 3 Cu and 0.07 max. C) especially for its resistance to sulphuric acid. The high copper content, valuable for H_2SO_4 service, is also likely to exist in a separate phase and ruin malleability, as pointed out in "Critical Points" in *Metal Progress* for February 1948, p. 225.

The improvement in hot workability by adding rare earths has been described by C. B. Post, D. G. Schoffstall and the present author in previous publications as well as by several others in numerous technical meetings, so that little has probably been left unsaid about this phase of the matter. However, to review it for those who are not familiar with this work, and to provide some thoughts for the others, we would like to discuss briefly some aspects of the effect on hot workability. Later, other influences of the rare earths will be considered.

First of all, let us consider what is meant by "rare-earth metals" and what is available for use as a rare-earth addition agent.

The rare-earth metals retain a name which is at once antique and erroneous. In alchemical days certain materials of earthy properties were thought to be elements when in fact they were difficultly reducible oxides we now know as alumina, zirconia and yttria. Lime was an "alkaline earth". Eventually it was discovered that these "earths" were oxides, but in the chemical texts of 50 years ago, aluminum and the metals in Group III of the periodic sequence (scandium, ytterbium, and elements No. 57 to 71) are called "the Earth Metals".

Neither are elements No. 57 to 71 rare. Large quantities of their oxides are recovered as a by-product of the treatment of monazite sand to separate thorium oxide. In fact, the U.S. Department of Defense Directive No. 4170.5 entitled "Comparison of Long-Range Scarcity of Certain Materials" under conditions of full mobilization ranks iron as 1.0, nickel as 20.5, rare earths as 80, molybdenum as 85 and cobalt as 230. Perhaps we can leave the subject by listing them:

Element No. 57	Lanthanum
58	Cerium
59	Prasodymium
60	Neodymium
61	Illinium
62	Samarium
63	Europium
64	Gadolinium
65	Terbium
66	Dysprosium
67	Holmium
68	Erbium
69	Thulium
70	Ytterbium
71	Lutetium

The first clear separation or "discovery" was of cerium by Berzelius in Sweden in 1803; the last was of illinium by a team of American researchers (Hopkins, Yntema) and a Canadian (Harris) in 1926.

Their chemical properties are so remarkably similar that separations of high degree of purity were almost unknown until work during the 1940's by Spedding at Ames (Iowa) Laboratory of the Atomic Energy Commission using ion exchange methods (described in *Metal Progress* July 1952, p. 67). A loan collection of pure metals is now established there.

Until recently, the most commonly used source of rare earths in stainless steels was misch metal, which is merely a mixture of the metals reduced from natural ore. Representative analyses fall within the range of 45 to 55% cerium, 22 to 30% lanthanum, 15 to 18% neodymium, up to 5% prasodymium, 2% other rare earths and 0.5 to 3% iron. There is available a misch metal with a somewhat higher lanthanum.

The other main type of addition agent is a mixture of rare-earth oxides together with a suitable reducing agent such as calcium boride or calcium silicon.

Each of these sources serves for improving the hot workability of stainless steels. However, the authors believe that a differentiation exists, since use of rare-earth oxides has increased the yield in prepared billets or in the finished product of such standard grades of stainless as Types 308 (20-12 Cr-Ni), 310 (25-20) and 316 (18-12), even though we have not been able to detect any residual rare-earth content in the steel. (It should be noted that these standard types are not inherently hot short, so that the improvement shown in this direction is of minor degree rather than of spectacular nature.)

Misch metal – which incidentally is about three times as expensive as rare-earth oxides – is no more potent on these standard grades of stainless than the oxides. Misch metal has its principal usefulness in those alloys which are inherently hot short, such as some of the analyses used for very high-temperature service and the sulphuric acid resistor mentioned above. In these alloys our experimental and production experience has shown that a residual rare-earth content is necessary for the maximum hot workability. The optimum content is a function of the base analysis and is mainly dependent upon the nickel content. This is shown in Fig. 2.

It can be seen that the higher the nickel content the lower the maximum tolerable content of rare earths. The minimum and maximum contents are altered within the broad ranges indicated by the additions of chromium, tungsten, molybdenum, and other useful elements. For instance, a commercial alloy of 28% nickel with 20% chromium, 3% molybdenum and 3% copper exhibits the best hot workability when the rare-earth content is between 0.10 and 0.35%.

The total rare-earth content is obtained by adding the anaylsis for cerium to the balance of the rare earths determined as lanthanum. We feel that the *total* is the important criterion rather than the content of any individual rare earth.

In summarizing this effect of rare-earth oxides and misch metal on hot workability, the following can be stated:

1. Misch-metal additions to high-alloy austenitic stainless steels, which are inherently hot short, can transform them into ductile alloys. Our experience has been that these alloys require cerium plus lanthanum to be 0.02% minimum.

2. Smaller misch-metal additions to low-alloy austenitic stainless steels (represented by Types 308, 310 and 316 which are inherently ductile) can improve hot workability as judged by higher yield of prepared billets or slabs.

3. Rare-earth oxide mixtures can improve the hot workability of inherently ductile austenitic stainless steels as evidenced by higher yields of prepared billet at a significant reduction of cost in comparison with misch-metal additions.

4. Rare-earth oxide mixtures do not improve hot workability of essentially hot short types of austenitic stainless steels or those which are difficult to hot work, even though residual cerium and lanthanum of 0.02% to 0.25% is generally beneficial.

5. The recovery of cerium and lanthanum from the commercial rare-earth oxide mixtures is small, if not altogether absent.

Mechanism of the Action

As with any metallurgical advance, an understanding of the mechanism by which the action progresses will increase the number of applications or improve the utility. However, it is not possible to propose an exact mechanism for the rare earths – only present some general observations on the over-all effect.

Removal of Oxygen – We have noted a definite effect of residual cerium and lanthanum on the oxygen content of the steel. (This is to be expected from thermophysical data, since the oxides of any of the rare-earth metals have a very high free energy of formation.) For example, we quote data for six 14-ton heats of Carpenter 20 to which 6 lb. per ton of misch metal was added to the stream while tapping into the ladle.

Oxygen Analyss		Residuals	
Ready to Tap	After Addition	Ce	La
0.006	0.003	0.098	0.096
0.011	0.004	0.085	0.082
0.011	0.003	0.079	0.053
0.008	0.003	0.067	0.046
0.006	0.002	0.077	0.075
0.008	0.003	0.077	0.060

However, simple removal of oxygen does not in itself promote desirable hot workability in inherently hot short alloys. The proof of this lies in the fact that smaller additions of misch metal, resulting in the same low final oxygen content but no residual cerium and lanthanum in the ladle analysis, would not promote the desired degree of hot workability.

Removal of Sulphur – Rare earths have a very definite effect on sulphur content. Extensive data, collected by Berger at the University of Pittsburgh, were presented at the 1954 annual meeting of the American Institute of Mining and Metallurgical Engineers. However, this is not necessarily of advantage in the commercial production of stainless steel, since its normal sulphur content is in the range of 0.010%. Sulphur in lower ranges does not greatly affect hot workability.

Grain Nucleation – Another theory is advanced particularly by Messrs. Tisdale Sr. and Jr. They have noted, in cooperative work with industry, a marked effect on primary grain crystallization by the use of rare earths, particularly in relatively large ingots. This may be a factor in the increased yield on Types 308, 310 and 316 already noted. We have not been able to note this effect at Carpenter Steel Co. on our smaller ingots, and feel quite sure that mere refinement of as-cast grain sizes is not a factor in converting inherently hot short austenitic stainless steels into commercially hot workable products.

Effect on Tramp Elements – We have noted, but not very conclusively, a beneficial effect of rare earths when tramp elements are present in such amounts as to cause difficulty in hot working. Since any of several elements (such as tin, lead, and silver) play a part in such a detrimental effect, it is exceedingly difficult to tie down an exact relationship of the rare earths.

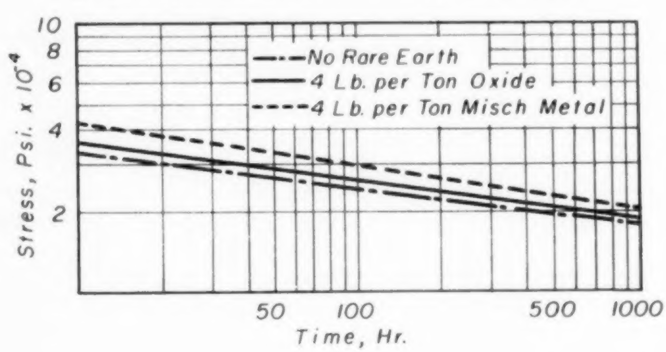
One explanation is that tramp elements form sulphides of such low melting point that they are molten at cogging temperatures, and that the rare earths convert these tramp element sulphides into others with a high melting point. This effect is probable, but misch metal does not consistently overcome the detrimental effects of tramps.

Hydrogen – In those steels which require a definite rare-earth residual to obtain the optimum hot workability, we believe that hydrogen plays some part. A high hydrogen content can nullify the beneficial effect of misch metal, but simple removal of hydrogen in itself does not produce the desired ductility. It is well known that hydrogen is an undesirable element in alloys that are very difficult to hot work.

Molybdenum and Copper – It appears that a definite residual rare-earth content is required mainly in those steels which contain considerable molybdenum, copper or both. It is common knowledge that molybdenum-bearing stainless steels are prone to excessive oxidation on heating, particularly in a stagnant atmosphere. Molybdenum oxide vapor acts as a catalyst for further oxidation. If this reaction is allowed to continue, the alloys can be completely destroyed – the so-called catastrophic oxidation. We believe that a definite residual of cerium and lanthanum in such alloys is required to prevent the diffusion of oxygen during heating for hot working. Oxygen might possibly form intermetallic compounds in the solid state which could have an extremely injurious effect on hot working.

Probably all of the before-mentioned factors play some part in the improvement of hot workability. Data are still unavailable to pinpoint the exact mechanism by which rare earths act so successfully.

Fig. 3 – Stress-Rupture Tests on Experimental Melts of Type 310, Tested at 1200° F., Show Strengthening Effect of Rare-Earth Oxides and of Misch Metal.



Properties Which Are Unaffected

So far we have discussed hot workability. Let us now consider what else rare earths can do. First, what physical properties are not affected by this addition?

Corrosion Resistance – Based on standard Huey tests on the standard A.I.S.I. types of stain-

less steels in the annealed condition, we have noted no effect on corrosion resistance. For example we cite corrosion rates on Type 310, annealed 30 min. at 2000° F. and water quenched, extrapolated from 240-hr. tests:

Treatment	Corrosion Rate	
	Mils per Yr.	In. per Mo.
No rare earths	3.96	0.00033
4 lb. oxide per ton	4.35	0.00036
4 lb. misch metal per ton	4.22	0.00035

The results for sensitized specimens of the unstabilized stainless steels are essentially the same; however, this test is meaningless for steels containing no carbide stabilizing element.

Tensile Properties– Using standard tensile test specimens in the annealed condition, we have not been able to note any effect of rare earths on tensile strength either at 70° F. or at temperatures as high at 1350° F. We have noted a slight effect of rare-earth additions upon ductility, with an average increase of about 4% in tests at room temperature.

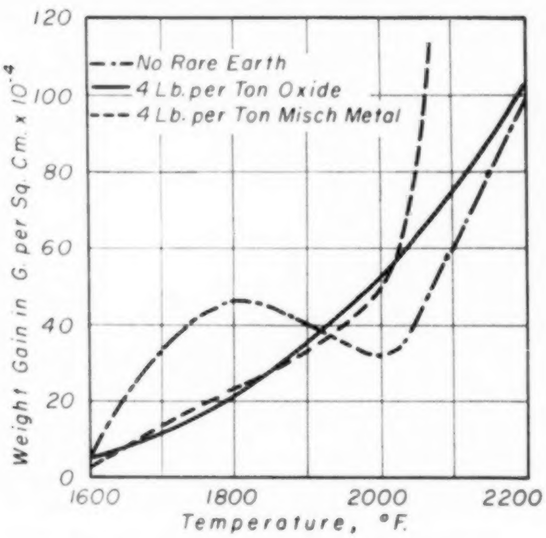


Fig. 4 – Scaling Effect of Rare Earths on Type 310 Stainless, Measured by Weight Gain After 100 Hr. in Open Atmosphere.

Impact Properties – Using V-notch Charpy impact specimens made of annealed stock, we have not been able to measure any consistent effect of either misch metal or rare-earth oxides. We have detected an increase for some alloys with misch-metal additions, but never any decrease in impact strength.

Age Hardening – After extensive experiments on the possibility that rare earths may act as precipitation hardening agents, we have not been able to note any beneficial or any detrimental effect on hardness.

Properties Which Are Affected

Now let us examine what physical properties are affected by rare-earth additions:

Stress-rupture is definitely increased, as measured by 4.5-in. specimens with a gage diameter of 0.25 in. and gage length 1 in., tested at 1200° F. up to 1000 hr. Figure 3 summarizes tests on Type 310. While the curves seem pretty close together, the logarithmic coordinates tend to mask the difference. For example, untreated Type 310 will endure 24,000 psi. stress for 100 hr. at 1200° F. before rupture, but after treatment with 4 lb. of misch metal the same alloy will endure 30,000 psi. for 100 hr. before rupture, a gain of 600 lb. or 25%. The respective figures for 1000-hr. life are 17,750 and 20,000 psi., a gain of 13%.

We believe that this effect is important. We also learned that the elongation and reduction of area values for stainless steels containing misch metal are higher at the same stress and temperature than when rare-earth oxides or no additions were made.

Scaling Resistance–The effect on scaling resistance appears to be very much dependent upon the base analysis. Space permits quotation of one run on samples continuously exposed for 100 hr. at 1600, 1800, 2000, and 2200° F. in open atmosphere. Weight-gain was used as a criterion of scale resistance in Fig. 4.

The beneficial effect of misch metal in reducing the scale formation up to about 1900° F. should be noted (dashed line). However, above this temperature the scaling rate increased rapidly. This same effect has been noted on other alloys, but not quite so marked. We cannot hazard a guess as to why such a reversal in effect should occur.

Conclusion

The rare earth elements definitely have a worth-while place in the production of wrought stainless steel alloys and possibly in other high alloys as well. They are not a cure-all, and do not substitute for good melting practice in producing the optimum of hot workability and physical properties. Steels with rare-earth additions have not, in our experience or experiments, been affected detrimentally in any way.

Brittle Failure of Steel Structures–

Brittle fractures in steel plate structures result from a combination of stress (residual, locked-in, thermal or working – not necessarily impact), stress concentration and triaxiality at notches, cracks or defects in workmanship, and steel of composition, microstructure and treatment which gives a high transition temperature for tough-to-brittle type of fracture.

As POINTED OUT in the historical article last month (p. 83), brittle failure of steel structures is not of recent origin, and cracking of steel plate in cold weather was reported in the *Journal* of the Iron and Steel Institute as early as 1879. Research in brittle failure is not new either. In 1884, L. Tetmajer, in Europe, carried out repeated-blow impact tests on notched T-beams. In the United States, S. B. Russel published in the *Proceedings* of the American Society of Civil Engineers for 1897 an account of a new impact testing machine and two years later an account of further work by him appeared in *Engineering News*. This account concluded that the shock resistance of mild steel could not be predicted from tensile strength and elongation, and that impact tests of the sort described by Russel might become valuable in judging the quality of structural steel. Charpy developed his pendulum impact testing machine on an extension of Russel's ideas.

In all of this early work the testing methods used to reveal brittleness employed impact loading. Thus the opinion arose, widespread even

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This paper is based, in part, on a report to the Committee on Ship Structural Design of the National Academy of Sciences, National Research Council. The Committee on Ship Structural Design is advisory to the interagency Ship Structure Committee which supported this investigation as part of its research program.

The complete report, "A Critical Survey of Brittle Failure in Carbon Plate Steel Structures Other Than Ships", was published as Report SSC 65 by the Ship Structure Committee, U.S. Coast Guard Headquarters, Washington 25, D.C. It is also available as Bulletin No. 17 of the Welding Research Council.

The opinions expressed in this article are those of the author and do not necessarily represent the views of the Committee on Ship Structural Design or the Ship Structure Committee.

Factors of Importance

*By M. E. SHANK**

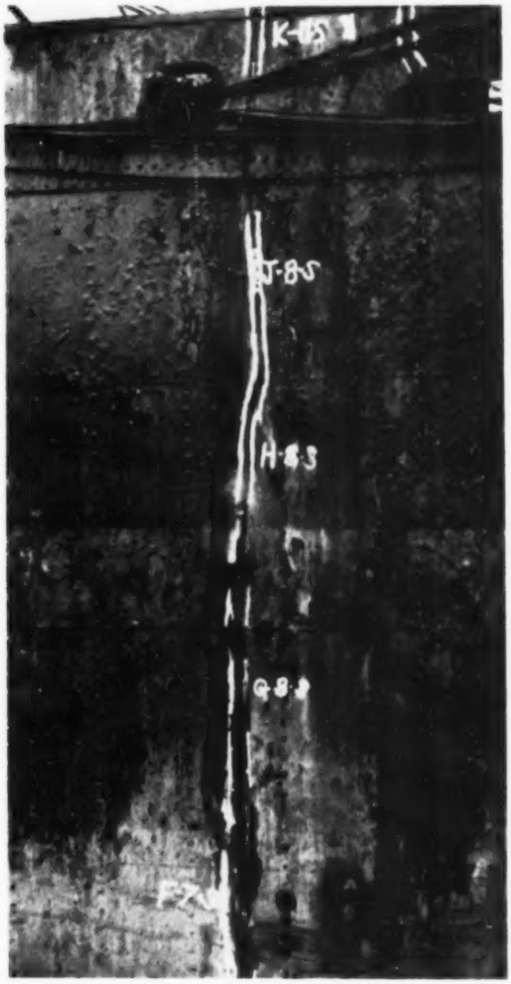


Fig. 1 – Crack in Ship's Plating, Bordered by Paint Lines, Which Crossed the Crack Arrester (Riveted Longitudinal Joint Near Top) in a Nearly Straight Line

in recent years, that brittle fracture in steels *resulted* from impact loading, even though it was known that if a specimen contained a sharp and deep notch, brittle failure could be induced by slow bending or slow tension. In 1906 A. Mesnager, making use of this observation, developed the theory of triaxial tension in notch brittleness.

Failures in Riveted Structures – Several failures of riveted structures occurred in the period between 1886 and 1904. Research work on notched-bar testing was developing over just that period, and even though brittle failure was reported in the *Journal* of the Iron and Steel Institute in 1879, the practicing engineer seemed to have been totally unfamiliar with the phenomenon. All of the early failures occurred in the colder part of the year. In all instances, the fractures were described as "brittle" or "glass-like". Hard and brittle steel was postulated as the cause. Investigation of chemical composition and tensile strength was urged. One failure was correctly related to cracks which radiated from punched rivet holes.

Of particular interest is the fact that, in at least three early cases of failure of nonship riveted structures, the crack appears to have crossed one or more riveted joints. At this late date the exact details are totally unavailable, but this historic fact is useful in appraising data from recent ship failures. Modified practice in the construction of welded ships requires the inclusion of several riveted, longitudinal "crack arresters", similar to butt straps used in riveted construction. All plate welds terminate at a slot behind these arresters. Of 250 vessels which suffered serious failures in the 1942-1952 decade,

77 were equipped with arresters. Of these 77 ships, 25 casualties did not involve the arresters in any way, and 46 involved cracks which were stopped by crack arresters. The remaining 6 vessels had cracks which restarted on the other side of crack arresters, the crossing of the arrester not necessarily being in a straight line. (See Fig. 1.) It is possible, therefore, for a brittle failure to cross a riveted joint, but it is obvious that crack arresters in ships have prevented a large number of cracks from propagating to a dangerous size.

Failures in Welded Structures – In comparing riveted and welded structures other than ships, failures seem to have occurred more frequently in the welded ones. This may be a totally deceiving conclusion, however, since no datum exists for comparison; structural methods have changed in intervening years; different materials are used; and the total number of riveted and welded structures is unknown. In the past, moreover, brittle failure probably has often gone unrecognized. For a speculative comparison, ship statistics may be examined for about 6000 ships built between 1938 and 1948. In that time there have been about four times as many welded ships built as ships with riveted hulls or decks. For the same materials of construction and essentially the same quality of workmanship, both the frequency and severity of fractures in ships increased as the amount of welding increased. Further, welded tankers have had much more trouble than dry-cargo ships.

Thermal Stresses – In 11 nonship welded failures, and in five riveted failures which have been studied and recorded, there had been a sharp atmospheric temperature change just prior to fracture. Two of these changes were rises, the remainder were drops. No data seem to be available on thermal stresses in tanks and pressure vessels, yet these stresses seem to be important in some degree. Thermal stresses have been responsible for initiation of several failures in ships. Shell failures have occurred in several tankers when oil in the tanks was being heated. Also a small coastal vessel suffered a fracture in zero weather when being launched into warmer water (32° F.). Refrigerator ships have had trouble in locations where all-welded decks were exposed in refrigerated areas at about 15° F. Thermal stresses in ships have been studied, but of course results cannot be applied directly to nonship structures. It is this author's opinion that thermal stresses in themselves, without additional factors (such as notches), are not too important. The point bears further investigation.

Residual Stresses – In eight cases of nonship failure, on-the-spot investigators blamed residual stresses. Little or no information is available on the measurement of residual stress in full-size nonship structures. Following the failure of a tanker at dockside in January 1943, much controversy was stirred up regarding the role of residual stress in brittle failure, and many investigations have attempted to evaluate residual welding stresses in butt welding of ship plate and locked-in stress* in ship assembly. The results indicate that the basic welding stress patterns are practically the same regardless of the type of ship or where it was built. Thus, these conclusions probably can be applied directly to nonship plate structures – at least in qualitative fashion. It was found, for example, that when a butt-weld bead was laid down, longitudinal tensile stress arose *along* the length of the center line of the deposited metal whose value approached the yield point. Values of transverse stress *across* the weld were found to be low, being from 2000 to 10,000 psi. in tension. Naturally, compressive stresses must exist somewhere in the parent plate to balance these.

Does the stressing of a pressure vessel in service, the loading and unloading of a bridge in traffic, cause local yielding of metal and relief of tensile stress in a weld? For nonship structures this question remains unanswered except for some scattered and probably unreliable measurements. In ships, however, it has been found that the magnitude of locked-in stresses is not reduced very much by the "working" of the ship at sea. Consequently, since all welded ships contain locked-in stress and these stresses are not reduced in service, and since only a fraction of the welded ships suffer casualties, locked-in stresses are not, by themselves, the prime cause of ship failures. Likewise, most nonship structures continue to stand undamaged despite their unquestioned possession of locked-in stresses.

This is not to say that no attention need be given them. In structures where defects exist, residual stresses must be reckoned with as being able to initiate failure either by themselves or, as is more likely, in combination with other factors. The recent failure of three new, unfilled oil-storage tanks in Europe by large cracks run-

* In ship reports it has been customary to define "residual stresses" as those resulting from the welding of unrestrained members; "locked-in stresses" include residual stresses and stresses resulting from other assembly and fabrication procedures.

ning across the weld could have been initiated only by residual stress. These cracks started in marks left by chipping chisels.

Undoubtedly, the full role of residual stress in helping to cause failure is not understood completely, even though there is evidence that stress relief will improve performance of material somewhat.

Table I – Effect of Metallurgical Variables on Transition Temperature (T.T.)

Factors Which Lower T. T.	Factors Which Raise T. T.
Deoxidation	Rimming nature
Small ferritic grain size	High finish temperatures in rolling
Normalizing	Boron
Higher manganese	Molybdenum
Low carbon	Silicon (above 0.25%)
Low phosphorus	
Aluminum residual	**Little Effect**
Nickel (slightly)	Chromium
Silicon (below 0.25%)	

Effect of Metallurgical and Fabrication Variables

As early as 1905 research workers turned their attention to the effect of composition and cold work on notch toughness. More recent work has confirmed, enlarged, and established in much more exact fashion the facts they found. For steels which are otherwise generally similar, a fully killed (deoxidized) steel will have a lower ductile-to-brittle transition temperature range than a semikilled or rimmed (nondeoxidized) steel. Decreasing the ferritic grain size, normalizing, and use of a lower finishing temperature in hot rolling all serve to lower the transition temperature range. Increasing the carbon and phosphorus contents markedly raises the transition temperature – thus promoting susceptibility to brittle failure in service at usual atmospheric temperature. Increasing the manganese content has the opposite effect. A little aluminum lowers the transition temperature, more causes no further change. Boron rapidly and regularly increases the transition temperature.* Chromium has little effect. Molybdenum increases the transition temperature almost as rapidly as increasing carbon. Nickel is slightly beneficial up to 1.80%. Increasing silicon (up to 0.25%) decreases the transition temperature; above this figure the transition temperature is increased by further silicon additions. High sulphur is usually associated with laminations, and such discontinuities increase the energy required for fracture in an impact test. These facts are summarized in Table I.

In view of the foregoing it would seem that the old practice of making steel plate from rimming steel may have contributed to some of the brittle failures. It also is indicated that the use of higher carbon steels, either inadvertently or deliberately to obtain high strength, may have been contributory. In general, effect of steel composition seems to have been neglected – at least as far as its effect on the possibility of brittle failure is concerned.

Effect of Cold Forming – Cold forming is a necessary step in fabricating almost all engineering structures, and two interesting studies have been made on this practice. The investigated steels were A.S.T.M. A-201 (killed) and A.S.T.M. A-70 (now A-285, rimmed). When cold worked 1% in the rolling direction it was found that the upper end of the transition temperature range was raised about 20° F. for the killed A-201, and about 60° F. for the rimmed A-70. (Transition range was determined by plotting keyhole Charpy impact test values against temperature of test piece.) This difference is probably due to the greater susceptibility to strain aging in the rimmed steel. Normalizing at 1600° F. consistently restored ductility and lowered the transition temperature. Heating to 1150° F. was not consistently effective, and heating at 500 or 800° F. only worsened the situation. Cold straining 20% in the rolling direction raises the upper end of the transition range by about 80° F. for both steels. Thus, the initial or moderate cold working is most damaging in this rimming steel, as far as raising the upper end of the transition is concerned, and more cold work has only a little more effect. In the killed steel, however, the temperature at which brittle fracture in the Charpy impact tests begins to appear is raised steadily and continuously by increased cold work.

No data seem to be available on the effect of cold forming on the transition temperature of steel taken from failed nonship structures, but even so, the implications of the foregoing research are clear. The work was performed on only two steels, and any generalization might be considered an over-optimistic extrapolation of the data. Nevertheless, extensive cold work tends

*It may be of interest to note that the Charpy transition temperature gives no indication of the transition temperature of a structure.

to contribute to susceptibility to brittle failure. Examples of such cold forming are the fabrication of high-yield pipe for gas lines, or the severe cold forming of pressure vessel heads.

Welding – As shown by several laboratory investigations, welding in itself contributes many metallurgical variables to the metal in the joint and in the heat-affected zone alongside. Moreover, behavior of the as-rolled plate gives no evidence of the characteristics of the welded material. Unfortunately, practically no data are available from failed nonship structures concerning the details of welding procedures. Also, little usable data seem to be available from ships. As a consequence, it is impossible to assess the role of metallurgical variables resulting from welding in the initiation of brittle failure.

Five Russian oil tanks which failed were erected and welded in extremely cold weather. This is known to reduce the ductility and toughness of weld deposits. In the failure of two bridges and of several ships, light welds on heavy plating with attendant quench cooling were no doubt a contributing factor.

Notched-Bar Impact Values in Failed Plates

Where data are available about plates from failed nonship structures, the Charpy or Izod energy values are quite low at the temperature of failure. Examination shows the following:

Fig. 2 – Relation of Energy Absorbed by Charpy V-Notch Specimens at the Temperatures of Ship Failures to Nature of Fractures in Ship Plates. (From "Investigation of Fractured Steel Plates Removed From Ships", by M. L. Williams and others, Document NBS-3 of Ship Structure Committee)

Hull Plates Containing Source of Service Fractures

2 out of 22 showed more than 10 ft-lb. Charpy

Number	Thickness	Temperature
3	0.44 to 0.69	40 to 58° F.
6	0.70 to 0.80	37 to 55
8	0.81 to 1.27	34 to 66
5*	0.41 to 1.50	20 to 35

Hull Plates Through Which Fracture Progressed

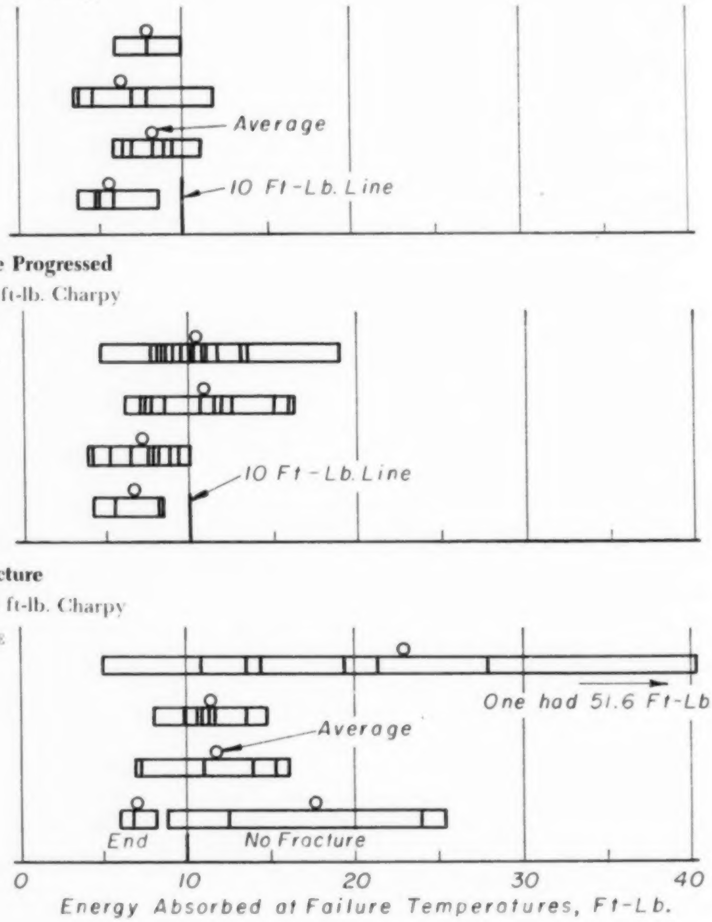
13 out of 41 showed more than 10 ft-lb. Charpy

Number	Thickness	Temperatur
15	0.44 to 0.69	0 to 78° F.
12	0.70 to 0.80	24 to 60
10	0.81 to 1.27	20 to 43
4*	0.41 to 1.50	32 to 54

Hull Plates Containing End of Fracture

21 out of 30 showed more than 10 ft-lb. Charpy

Number	Thickness	Temperature
9	0.44 to 0.69	0 to 67° F.
8	0.70 to 0.80	32 to 70
6	0.81 to 1.27	37 to 66
7*	0.41 to 1.50	30 to 49



*These are miscellaneous plates from other parts of the ship.

Number of Tests	Impact Energy
4	Less than 5 ft-lb.
2	Between 5 and 10 ft-lb.
2	Between 10 and 15 ft-lb.

In the remaining cases the data are not in such form as to show the energy at the temperature of failure.

No statistical interpretation can be made of so small a sample. It seems to be in line, however, with data obtained in the investigation of fractured plates from welded ships, which divided plates into three categories: *(a)* "source" – a plate in which fracture originated; *(b)* "through" – a plate through which a fracture traveled; *(c)* "*end*" – a plate in which a fracture terminated. The highest value of impact energy for a "source" plate in a ship failure was 11.4 ft-lb. at the temperature of failure. Of 22 "source" plates only two, or 9%, had energies over 10 ft-lb. For "end" plates, or plates with no fracture, 21 out of 30 plates, or 70% showed more than 10 ft-lb. at temperature of failure. These data are shown and tabulated in Fig. 2.

Further, of 31 plates wherein the fracture started, only 10%, or 3 plates, had 15 ft-lb. transition temperatures below 70° F. Of 82 plates which did not contain fracture sources, 67% had 15 ft-lb. transition temperatures below 70° F. The report from which these figures are derived ("Investigation of Fractured Steel Plates Removed From Ships", by M. L. Williams and others, Document NBS-3 of Ship Structure Committee)* is a most valuable one and its perusal is most highly recommended to those interested. It is to be noted that all of these studies were on semikilled or rimmed steel within a narrow range of composition.

In considering results of notched-bar tests, it is interesting to note that dirty steels of poor quality often have higher impact values than "good" steels. This was noted by Mesnager who, in 1906, observed that embedded inclusions cause individual metal laminations to separate from each other, preventing a brittle crack from traversing the specimen. He also noted the fact that gas holes caused a similar effect. Fettweis stated in 1929 that faulty material can have a higher impact resistance than sound material. The action of high sulphur in inducing laminations leads to the same effect. Wrought iron owes its toughness to its highly laminated structure.

Another interesting fact is that "brittle" fractures (mainly cleavage) can be obtained in the laboratory even though the energy absorbed has a high value. This is probably related to the fact that cleavage fractures can be propagated with a velocity as low as 150 ft. per sec.

Role of Cracks, Defects and Stress Concentrations

Structural defects are most important factors in brittle failure. In nonship structures (both riveted and nonriveted) for which data are available, the preponderance of failures have been initiated at cracks left by punching or shearing, at plate offsets, voids in welds, poor weld-probe replacements, poorly repaired welds, and at defects resulting from improper fabrication procedures. Only two known failures were initiated solely by the effect of stress concentrations designed into the structure, and modifications of the design seem to have eliminated subsequent failures. Some structural failures probably have been initiated by a combination of design and fabrication defects.

In the welded ships built during World War II, however, fractures often originated at points where poor welded design practice (such as sharp hatch corners in the Liberty ships) had been utilized. After the design had been corrected, the origins of most recent failures in these ships have been traced to defective workmanship. It was also concluded that every ship fracture investigated could be traced to a starting point at a definite geometrical discontinuity due to design or workmanship. Although the data are not complete for nonship structures, it would appear that the latter conclusion is equally valid

*The references on which these articles are based are too numerous to permit their listing in full. Complete bibliographies will be found in the following:

"A Critical Survey of Brittle Failures in Carbon Plate Steel Structures Other Than Ships", by M. E. Shank. Report to the Committee on Ship Structural Design, National Academy of Sciences – National Research Council. Published as Ship Structure Committee Report SSC 65, January 1954, and as Bulletin No. 17 of the Welding Research Council.

"Review of Welded Ship Failures", by H. G. Acker, Report to Committee on Ship Structural Design, National Academy of Sciences–National Research Council. Published as Ship Structure Committee Report SSC 63, December 1953.

"Brittle Failure of Non-ship Steel Plate Structures", by M. E. Shank, *Mechanical Engineering*, January 1954, p. 23.

Third Technical Progress Report of the Ship Structure Committee, August 1953.

"Die Kerbschlageprobe – Entwicklung und Kritik", by F. Fettweis (translated from the German by L. Emerich and E. P. Klier and distributed by the Ship Structure Committee, U.S. Coast Guard Headquarters, Washington 25, D.C., April 1951).

here. The importance of workmanship cannot be overemphasized. One ship is known to have broken in half as the result of a fracture initiating at so small a thing as a crater left by an arc strike. Equally small defects are known to have initiated nonship failures.

Crack Paths – A word might be said here about the path of a brittle crack, once failure has been initiated. Unless a weld is exceptionally bad, there is no tendency for a crack to follow welded seams. In fact, in a 38-ft. spherical welded pressure vessel, there were 650 ft. of brittle tears and 20 fragments. Only a few feet of fracture followed either the welded seams or the heat-affected zone.

Age – There seems to be no correlation between the age of a structure and the occurrence of brittle failure. This conclusion was found to be statistically valid in the study of ships.

Static Versus Impact Stresses – As noted above, the historical fact is that the development of the notched-bar impact test has led to the association of brittle failure with impact. In the nonship structural failures, only five out of 64 could be definitely connected with the phenomenon of impact. Indeed, about 10% of all serious brittle ship failures occurred at dockside or in a calm sea. Of course, the majority of ship failures occurred during heavy weather and near-freezing temperatures. However, the record demonstrates that brittle failure can occur under apparently static loading if the proper conditions of temperature, triaxiality (notches) and stress are present in the structure.

Codes and Specifications

It was not within the scope of this article nor was it the intention of the author to pass judgment on codes or specifications. They are usually the product of long and careful deliberation, and are conservatively based on experience in service. This survey, however, would lack orientation if it did not mention some of the codes under which engineering structures often are fabricated, or some of the specifications under which materials are usually purchased.

The American Society of Mechanical Engineers (A.S.M.E.) and the American Petroleum Institute (A.P.I.) have formulated the A.S.M.E. and the A.P.I.-A.S.M.E. unfired pressure vessel codes. These codes and certain codes of the American Water Works Assoc. (A.W.W.A.) and the American Standards Assoc. (A.S.A.) as well as certain standards of the American Society for Testing Materials (A.S.T.M.), were examined. All of these except the A.S.A. code for gas transmission lines require quite conservative design stresses, usually about 25% of the ultimate strength. All of the codes permit a wide variety of A.S.T.M. designations of steel plate to be used, and some of these (for example, Types A-7 and A-285) can be furnished rimmed, semi-killed or killed. Some A.S.T.M. specifications do not set any limit on carbon content; others set a very high limit. A.P.I. Standard 5 LX for gas transmission line pipe allows carbon contents and (under certain circumstances) phosphorus contents which are quite high. Both A.P.I. and A.W.W.A. codes allow partial penetration of welded horizontal joints in storage tanks – and, so far as is known, such practice has never led to any mishap.

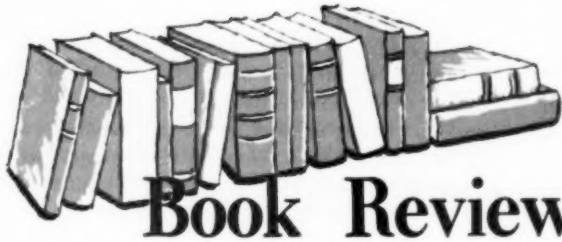
In 1947, the American Bureau of Shipping (A.B.S.), because of the high incidence of ship failures, established specifications for steel plate over ½ in. thick which put very definite limits on carbon and manganese contents, and which require that plate over 1 in. thick be made to fine-grain practice. Chemical composition of plate less than ½ in. thick is limited only in phosphorus and sulphur – which recognizes the fact that there have been no recorded failures in small ships built of lighter plate. Several industrial organizations have indicated their intention of using in the future the A.B.S. steels for heavier plates in such varying structures as oil tanks, power shovels, and smokestacks.

The foregoing remarks merely serve to point up some of the designer's difficulties and the problems of steel selection and use in nonship engineering structures to avoid possibility of brittle failure in service.

Conclusion

From the foregoing, it is evident that brittle failure results from a combination of many factors. No commercial material is now readily and economically available which would, if built into bridges, pressure vessels, and other structures, totally prevent the occurrence of brittle fractures. Finally, there is no known test which will surely predict, from the behavior of small specimens, the performance of a given structure in circumstances where brittle failure might occur.

In short, careful design, selection of material, and good workmanship are of the greatest importance in the prevention of brittle failure in carbon plate steel structures.



Book Review...

Seminar on Gas-Metal Phenomena

*Reviewed by CARL A. ZAPFFE**

GASES IN METALS; 204 p., 98 illustrations; American Society for Metals, Cleveland. 1953. $3.

IN RESPONSE to a growing interest in gas-metal phenomena, the Educational Committee of the American Society for Metals arranged for a seminar to be held on this subject at the National Metal Congress in 1953. It seems only a very few years since the A.S.M. was first organized as the American Society for Steel Treating. World War I had just concluded with an armistice; during that war a major catastrophe, both metallurgical and military, had arisen with regard to "flakes" in heavy forged pieces and "woody fracture" in armament – particularly that manufactured in the United States. Two million American soldiers were in France, but the heavy forgings had to be provided by our allies!

Not until the eve of World War II did it become established that the gas hydrogen was a prime operator in flaking, and the war was about over when the role of nitrogen was clearly established in regard to a serious occurrence of "woody fracture", and hydrogen was further shown to be a cause of underbead cracking in steel welds. In the meantime, an extensive literature had developed with regard to such matters as oxygen in steel, and numerous effects of gases in the nonferrous metals.

For the sake of a comprehensive coverage in this symposium, the entire field was divided into quadrants, and four speakers of renown were selected, each to summarize his respective section, further digressing upon specialties of his own selection. The seminar was opened by Prof. D. P. Smith of Princeton University, who sketched the physicochemical principles underlying gas-metal reactions in general; he was followed by L. W. Eastwood, assistant director of research for Kaiser Aluminum and Chemical Corp., who spoke on nonferrous problems. The remaining speakers, D. J. Carney (chief development metallurgist at South Works, U. S. Steel Corp.) and C. E. Sims (assistant director of Battelle Memorial Institute) divided the ferrous field conveniently between considerations of the liquid and of the solid state.

The present book contains their four papers.

Smith's very short opening chapter dwells principally on hydrogen, less on nitrogen, and very briefly on the other gases. His treatment is physical rather than thermodynamic, emphasizing the characteristics of exothermic and endothermic systems, and the nature of absorption and fusion – particularly from the viewpoint of "rift occlusion". The paper is a short brief of his 1948 book "Hydrogen in Metals", running only to 18 pages with 20 references. A three-page discussion by his associate, Ernest Birchenall, is appended.

Similarly, Eastwood in the second chapter takes twice as much space to brief his 1946 book

*Dr. Zapffe, consulting metallurgist of Baltimore, Md., appears as author of no less than 15 of the documents cited in the two chapters on gases in steel. He has done outstanding work on "hydrogen embrittlement".

"Gas in Light Alloys", although the treatment naturally has more meat than the preceding chapter. He is principally concerned with aluminum and magnesium, although a little attention is also given to copper, titanium, zirconium and molybdenum. Reactions producing the gases which are absorbed during melting, means for removing this gas from the liquid metal, and mechanical effects of porosity get first attention.

As the book progresses, its contributions rapidly increase in size and scope. Carney's chapter is a particularly good coverage of hydrogen, oxygen and nitrogen in liquid iron and steel – insofar as that field can be briefly given. There are no less than 88 references thought worthy of noting, which is a small indication of the amount of work done on this subject.

Sims's closing chapter is the outstanding contribution of the book, running to 80 pages, with 81 references and 53 figures. It will be found

Hydrogen Embrittlement of a

Recent failures of titanium alloy components have been ascribed to hydrogen, and it is demonstrated here that this interstitial element lowers the tensile ductility of the 3% manganese complex alloy, the effect becoming most pronounced with decreasing strain rate at room temperature.

RECENTLY, during the expanded commercial production of titanium and its alloys, the role of interstitial elements such as carbon, oxygen, and nitrogen has been intensively studied and their effect upon the mechanical and processing characteristics of the metal has been quite well defined. Generally, their usefulness as alloying elements has been overshadowed by their deleterious effects. The majority of the work has been confined to these stabilizers of the alpha phase, to the near exclusion of the beta-stabilizing interstitial element, hydrogen.

The critical role of hydrogen was first uncovered at Battelle Memorial Institute. The work of Lenning, Craighead and Jaffee published in the *Journal of Metals* for March 1954 (p. 367) on iodide-base titanium and commercial alpha titanium indicated that hydrogen up to 1.1 at.% (240 parts per million) was not detrimental to the tensile ductility but did decrease notch toughness. In an alpha-beta alloy, RC 130 A, the tensile ductility was shown to drop radically at about 2 at.%. In a separate project, also at Battelle, Frost and his associates ascribed poor ductility in sheet alloys to the presence of hydrogen as determined by metallographic evidence and by vacuum annealing treatments. This work is contained in Wright Air Development Center Technical Report 54-205, Jan. 7, 1954.

The marked effect of strain rate on tensile ductility of alpha-beta alloys of titanium was first encountered during the testing of the 3 Mn

*Materials Laboratory, Wright Air Development Center, Air Research and Development Command.
The authors wish to express their gratitude to R. I. Jaffee, P. Frost of Battelle Memorial Institute and to H. K. Adenstedt for their advice and assistance, and to Messrs. Shinn, Rowand and Klinger, of the Materials Laboratory, Directorate of Research, Wright Air Development Center, who set up the testing procedures and carried on the testing program.

particularly useful as the best single and inclusive exposition of Sims's own viewpoints and contributions on numerous gas phenomena in solid iron and steel — along with those of others which he discusses. His statements with regard to flakes or shatter cracks, underbead cracking in welds, intergranular fracture from aluminum nitride precipitation — to mention only four — accurately represent the best current thought.

To summarize: This is no textbook on the subject of gases in metals. Rather it is a collection of four manuscripts by first-rate authorities whose topics span the whole broad field, and touch lightly on important areas. There is little if anything original to be found in the book. Its principal value is in an authoritative and concise statement about considerations whose discussion would burden the reader with thousands of pages of the greatest variety of opinions, many of them often conflicting.

Titanium Alloy

*By Major R. J. KOTFILA and Lt. E. F. ERBIN**

complex titanium alloy (3 Mn, 1 Fe, 1 Cr, 1 V, 1 Mo) when two laboratories reported different tensile ductility figures. In an attempt to resolve the discrepancies between the two sets of data, the authors varied the strain rate with the following results:

Testing Speed	Reduction in Area	Elongation in 1 In.
0.005 in./min.	8.5%	5%
0.01	16.5	12
0.10	42.0	15

By increasing the strain rate 20-fold, elongation was doubled and reduction in area quadrupled. It was decided that a more intensive investigation of this phenomenon was needed, and recent engine failure has emphasized the need for a fuller understanding of the effect of hydrogen in titanium.

Testing Program—A program was therefore undertaken at the Materials Laboratory, Directorate of Research, Wright Air Development Center, to determine the effects of the three controlling variables, (*a*) hydrogen level, (*b*) strain rate, and (*c*) testing temperature, upon the mechanical properties of the 3 Mn complex titanium alloy. The actual analysis of the metal was 3.79% Mn, 1.49% Cr, 1.06% Fe, 1.16% Mo, 1.13% V, 0.015% C, 0.019% H, 0.021% N, and remainder titanium.

This alpha-beta alloy was double-melted by the Bureau of Mines by the method described in *Transactions*, 1953, p. 862, by Stephens, Gilbert and Beall. It was rolled to ⅞-in. rounds in the beta region (1550° F.), vacuum annealed and then finished rolled to ½-in. rounds in the alpha-beta region (1400° F.). Vacuum annealing was done at 1400° F. for 12 hr. at temperature in a vacuum of less than 0.03 micron. Subsequently it was rehydrogenated in various amounts, machined to 0.250-in. gage diameter tensile specimens, and heat treated to a strength level of 170,000 psi. ultimate. Heat treatment consisted of solution treating at 1300° F. for 1 hr., water quenching and aging for 8 hr. at 900° F. followed by air cooling. The hydrogen levels investigated were 30, 120, 200 and 300 parts per million, with a tolerance of 20 ppm.

Tensile testing was done in a liquid bath to assure constant temperature at −107, 75 and 190° F. ± 3°. Loading was controlled by a strain pacer calibrated to give constant head speeds. After preliminary testing, the rate of straining necessary to delineate the strain rate sensitivity of the alloy covered the range from 0.005 to 0.5 in. per min., a factor of 100. Ultimate strength, elongation in 1 in. and reduction in area were determined.

Results—In Fig. 1, 2, and 3, the reduction in area is plotted against temperature for each of the three testing speeds, and clearly demon-

strates the effect of the hydrogen and strain rate upon the tensile ductility of this titanium alloy. The transition from ductile to brittle fracture is shifted markedly toward higher temperatures with increasing hydrogen contents. These results are suggestive of a strain aging process involving hydrogen, and corroborate earlier suspicions regarding this phenomenon.

At the slower strain rates (0.005 and 0.05 in. per min.) the transition appears at or above room temperature if the metal contains 200 ppm. hydrogen or more. At a higher strain rate (0.5 in. per min. in Fig. 3) the ductility is almost totally restored to that of the base material for hydrogen levels up to 200 ppm; however, the ductility of the metal containing 300 ppm. of hydrogen is still seriously impaired at this high strain rate and the transition temperature is considerably above room temperature. At a testing temperature of 200° F., the effect of strain rate is not so pronounced, and only at the slowest strain rate (Fig. 1) is the ductility noticeably affected by hydrogen as high as 200 ppm. As pointed out previously, the material with 300 ppm. hydrogen suffers a loss in ductility at all strain rates even at 200° F. A minimum in the ductility vs. temperature curve appears near room temperature for the slower testing speeds. As the temperature decreases below this range, the ductility shows some improvement over that found at room temperature.

It was observed that the ultimate tensile strength changes little with testing speeds irrespective of the hydrogen content. It was deduced from this that whatever the embrittling reaction is, it occurs *beyond* the highest load in a tensile test – in other words, during necking. To confirm this suspicion that embrittlement requires a slow strain rate during the portion of the stress-strain curve beyond the ultimate load, a series of tests was run on metal containing 200 ppm. hydrogen, using the following combinations of testing speeds during the test:

1. 0.5 in. per min. testing speed to a load slightly below the ultimate load, hold at that point for 15 min. and continue at 0.5 in. per min. to fracture. The delay was to allow time for any precipitation to take place. The result was a ductile fracture.

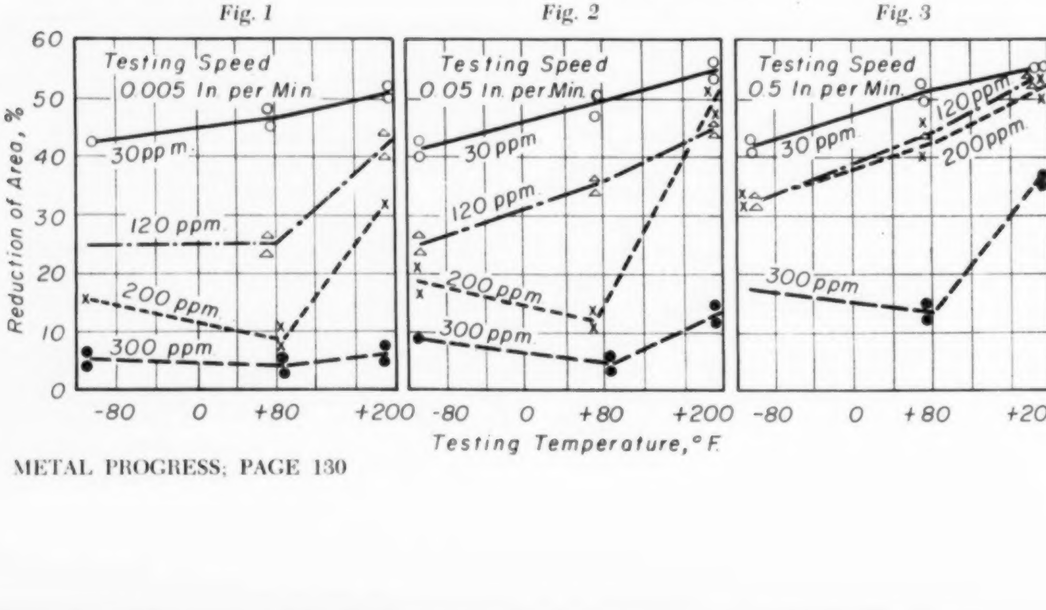
2. 0.5 in. per min. testing speed to a load slightly below the ultimate load; the strain rate was then lowered without delay to 0.005 in. per min. and continued at this slow rate to fracture. The result was a brittle fracture.

3. 0.005 in. per min. testing speed to the ultimate load; then the strain rate was increased to 0.5 in. per min. to fracture. The result was a ductile fracture.

In each of the above tests, the ductility of the metal depended upon the testing speed *beyond* the ultimate load. However, embrittlement could conceivably occur at stresses below the ultimate strength if sufficient time were to elapse while the metal is under load. Notched stress-rupture tests show that premature failures do occur in hydrogen-bearing material.

Discussion – Ductility characteristics of the 3 Mn complex titanium alloy heat treated to a high strength level, and containing hydrogen in quantities greater than approximately 100 ppm. is governed by two competing factors: One of

Plots Showing Relationship of Hydrogen Content, Strain Rate (Testing Speed) and Tensile Ductility (Reduction in Area of a 0.250-In. Test Piece) in a Semicommercial Alloy Nominally 3 Mn, 1 Fe, 1 Cr, 1 V, 1 Mo.



these is the embrittling action of the hydrogen, which occurs as a strain aging phenomenon during the straining of the specimen; the other factor is the rate of deformation of the material.

The exact nature of the embrittlement is unknown. If it is a strain aging phenomenon, as suggested, the reaction would be a diffusion process and therefore dependent on time and temperature. It may be further postulated that, with the faster strain rates, the reaction has insufficient time to progress and little hydrogen precipitates. On the other hand, with slow strain rates (tensile tests taking 1 hr. or more) the reaction has time to proceed. The variation of ductility with strain rate could be interpreted in this manner, that is, the time-dependent portion of the diffusion process.

The effect of temperature is apparent from the fact that the curves of reduction in area versus temperature show an upward slope below room temperature at slow strain rates. The embrittling process becomes less prominent as the temperature decreases. This conforms to laws governing diffusion-dependent processes.

Above room temperature the embrittling action becomes less effective and the ductility is not so markedly decreased. It is also known that above about 200° F. the solubility of hydrogen in alpha titanium increases rapidly with temperature. In a beta-stabilized titanium alloy like the one used in this investigation it may be expected that solubility of hydrogen would increase at temperatures lower than those for alpha titanium. This would explain the fact that the embrittlement decreases in severity above room temperature for the 3 Mn complex alloy.

Commercial uses of titanium depend on its ability to maintain a useful combination of strength and ductility under rather severe operating conditions. It has been shown that contamination by hydrogen seriously impairs the normal tensile ductility of titanium. The theory that the embrittling action is a time-dependent process suggests that titanium may lose its normal ductility when exposed for long periods of time to stresses lower than the ultimate stress. This is verified by information obtained from other laboratories concerning notched stress-rupture tests at room temperature on a hydrogen-bearing commercial titanium alloy, run at 60,000 psi. – a stress far below the yield stress – which resulted in brittle failure after only 2 hr.

This condition assumes practical significance when one considers that hydrogen-bearing titanium alloys subjected to nominal design stresses in service applications may have their mechanical properties seriously impaired. Consequently, they may lose their useful engineering properties when contaminated with this interstitial element.

Considering the above data it can also be seen that the significance of the testing speed in a tensile test of titanium alloys cannot be overemphasized. Variation in testing speeds could result in a discrepancy in ductility values among different tests of the same material. This is obviously an undesirable situation. Previous situations in which producers and manufacturers could not agree may very well have been caused by this variable. Obviously, some standardized testing procedures must be established. When this is done, many of the current titanium complexities may be eliminated.

From the standpoint of quality control the slow-speed tensile test may demonstrate the worst possible condition of the material being evaluated. There is evidence that a ductility transition range exists for the vacuum annealed material. Obviously, for the curves of higher hydrogen content (Fig. 1 to 3) the effect of hydrogen is to superimpose an embrittling action upon the normal transition characteristics of the alloy. The loss in ductility occurs at higher temperatures with increasing hydrogen. It has been proposed that the transition range of any specific alloy, as determined by slow tensile tests, be used as the criterion for the amount of hydrogen the material can tolerate without having its ductility properties seriously impaired.

Conclusions

The embrittling effect of hydrogen upon the properties of the semicommercial 3 Mn complex titanium alloy (3% Mn, 1 Fe, 1 Cr, 1 V, 1 Mo) has been investigated. The reduction in area of the specimen is the tensile property most sensitive to hydrogen. Embrittlement, as measured by reduction of area at the fracture, seems to be a diffusion-dependent process with a rate maximum in the vicinity of room temperature. Tensile results are strain-rate sensitive; slow rates of deformation give brittle fractures while rapid rates of loading give ductile fractures. The rate of deformation beyond the ultimate load is most influential. Agreement on standards for tensile testing procedures is needed.

It appears urgently necessary to determine the effect of hydrogen contamination on the properties of the various commercially available titanium alloys.

Nickel Plating From Sulphamate Baths

*By MYRON B. DIGGIN**

Nickel plated from sulphamate-chloride solutions containing an organic addition agent has compressive internal stresses, high tensile strength, and hardness without brittleness. Possible applications are mentioned.

NICKEL PLATING from sulphamate solutions is a recent practice, its first significant commercial use beginning in 1950 with the introduction of the process of R. C. Barrett to the electrotyping industry. Some work had been done with sulphamate electrolytes prior to this, the earliest report having appeared in 1938, and a U.S. patent for plating from such solutions, including nickel sulphamate, being granted in 1940. The process of sulphamate plating from that time until 1950 received the attention of only a few investigators.

The two solutions studied in our laboratory vary considerably from the composition of the bath recommended by Barrett. The formulas for these solutions are shown in Table I.

The function of the nickel sulphamate is to supply nickel ions to the solution. The amount used can be varied between 36 and 44 oz. per gal., with faster deposition occurring at the higher concentrations. Nickel chloride maintains the nickel content of the bath by promoting anode corrosion, thus minimizing harmful oxidizing effects at the anodes. Boric acid gives a buffering action in the cathode film. The addition of an organic agent (SN-1) increases hardness, changes internal stress from tensile to compressive, and increases the tensile strength and the electrical resistivity of the nickel deposit. This addition agent produces the desirable characteristics in the deposit without the brittleness or

*Technical Director, Hanson-Van Winkle-Munning Co., Matawan, N. J.

Table I – Compositions of Three Nickel Sulphamate Baths

Constituents	Barrett's Solution	Bath No. 1	Bath No. 2
Nickel sulphamate	40*	40*	40*
Nickel chloride	—	4	4
Anti-pit agent	0.05	—	—
Buffer	0.25	—	—
Boric acid	3	4	4
SN-1	—	—	1

*Oz. per gal.

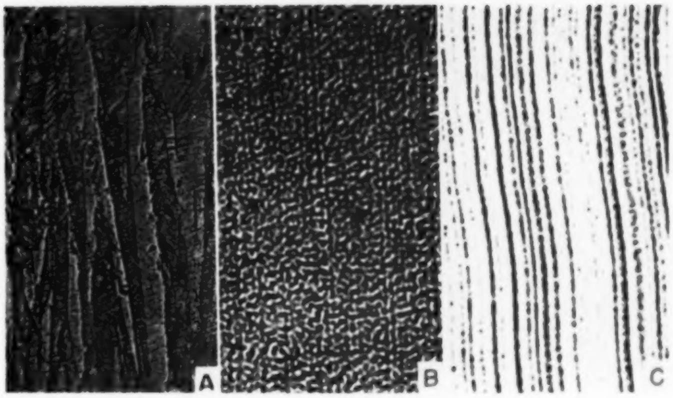


Fig. 1 – (A) Structure of Nickel Deposit From Sulphamate Bath at 80° F.; (B) Deposit From Bath Containing 28 G. Addition Agent (SN-1) per Gallon of Solution; (C) Higher Plating Temperature, 140° F., Produces a Finer Structure From Bath Containing Same Amount of SN-1. 1000×

loss of ductility so often caused by many other organic compounds.

Plating baths 1 and 2 are prepared by dissolving the chemicals in water, adding 4¾ ml. of hydrogen peroxide for each gallon of solution, after which the temperature is raised to 140° F. The pH is adjusted to about 5.5 by adding a slurry of nickel carbonate. Approximately 8.5 g. of activated carbon is then stirred in for each gallon of solution, which, after standing a few hours, is filtered back into the plating tank. The bath is then electrolyzed using a corrugated cathode at a current density of about 2 to 5 amp. per sq.ft. for approximately 14 hr. If the dummy cathode does not display a uniform gray nickel deposit in the low current density areas, the electrolysis should be continued until such a deposit is obtained. At this time the pH is adjusted to 3.5 to 4.2 (electrometric) by adding a purified solution of sulphamic acid. The organic addition agent (SN-1), if used, is then added to the bath.

The normal operating conditions for these two baths are as follows:

Temperature	75 to 160° F.
Current density	20 to 140 amp. per sq.ft.
pH	3.5 to 4.2 electrometric
Agitation	Air from a low-pressure blower
Filtration	Continuous

Fig. 3 – Effects of Increasing Current Density to 140 Amp. per Sq. Ft. Upon Structure Obtained From Bath Containing SN-1. 1000×

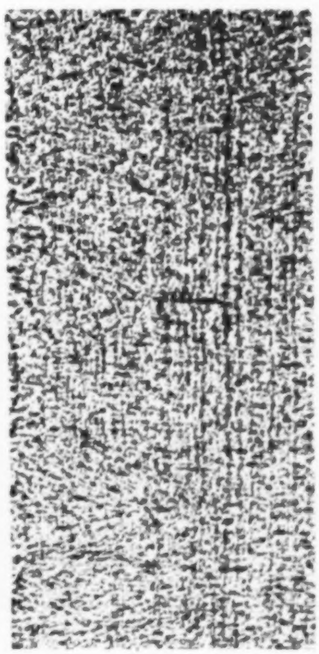
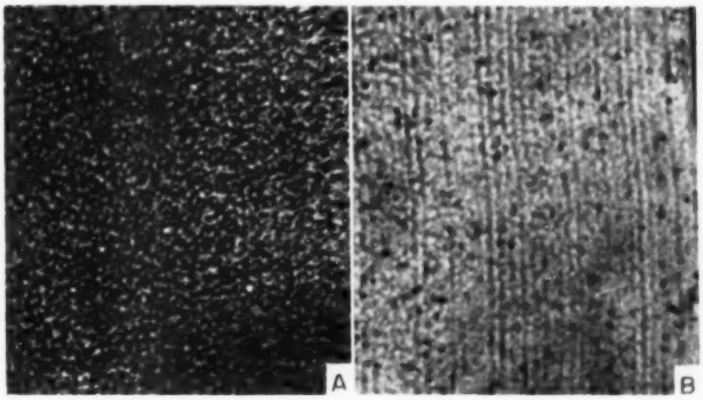


Fig. 2 – Structure of Nickel Deposits From Sulphamate Baths Containing 28 G. SN-1 per Gallon of Solution Using (A) 20 Amp. per Sq.Ft., (B) 80 Amp. per Sq.Ft. 1000×



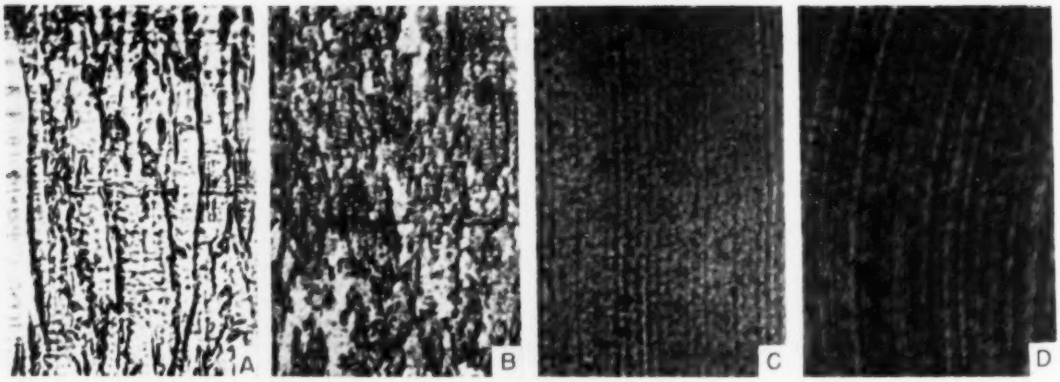


Fig. 4 – Structure of Nickel Deposits From the Straight Sulphamate Bath (A), and From Bath Containing 14 G. SN-1 per Gallon of Solution (B); Bath at 120° F. and 60 Amp. per Sq.Ft. Structure shown in (C) was from bath having 28 g. SN-1 and (D) was from bath with 42 g., both baths operated at 120° F. and 80 amp. per sq.ft. 1000×

Effects of Operating Conditions

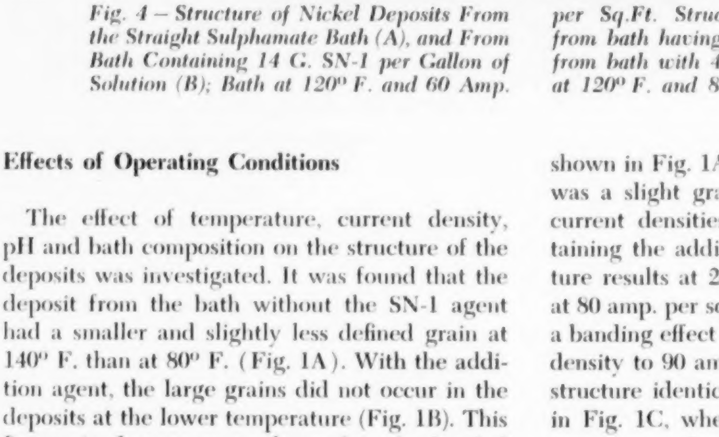
The effect of temperature, current density, pH and bath composition on the structure of the deposits was investigated. It was found that the deposit from the bath without the SN-1 agent had a smaller and slightly less defined grain at 140° F. than at 80° F. (Fig. 1A). With the addition agent, the large grains did not occur in the deposits at the lower temperature (Fig. 1B). This fine-grained appearance changed to the banded structure shown in Fig. 1C for the deposit obtained at 140° F.

Current density of 20 amp. per sq.ft. produced a coating having a structure similar to that shown in Fig. 1A, and at 80 amp. per sq.ft. there was a slight grain refinement. When the same current densities are used with the bath containing the addition agent, a fine-grained structure results at 20 amp. per sq.ft. (Fig. 2A), and at 80 amp. per sq.ft. the structure begins to show a banding effect (Fig. 2B). Increasing the current density to 90 amp. per sq.ft. produces a banded structure identical in appearance to that shown in Fig. 1C, whereas for current density of 140 amp. per sq.ft. the structure acquires the fine-grained character shown in Fig. 3 with the banding just perceptible.

An increase in the pH of the sulphamate bath has the same effect on the deposits as occurs in the Watts-type nickel bath, the increase causing changes in stress and hardness of the coating and the formation of a fine-grained structure.

Minor variations in the content of total nickel, nickel chloride and boric acid in the bath have little observable effect on the structure of deposits, but the effect with varying concentrations of the addition agent used is very evident. As the amount of the agent is increased, a progressive refinement of the grain size occurs and banding becomes more pronounced, as shown in the series of micros in Fig. 4.

Fig. 5 – Effect of Current Density at 100° F. on Stress in Deposit.



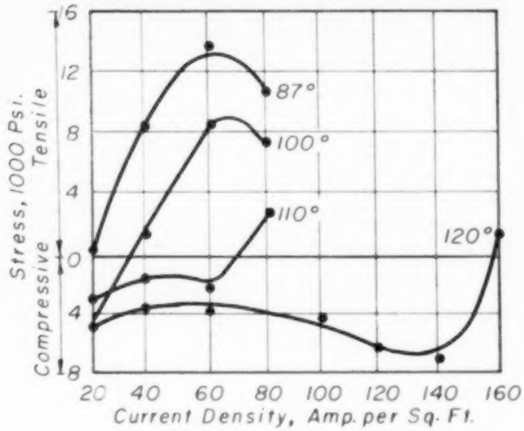


Fig. 6 – Effect of Current Density and Temperature of Bath on Stress in Deposits. Bath contained 28 g. SN-1 per gallon of solution

Physical Properties of Deposits

Stress – The presence of stress is of concern to electroplaters, especially in electroforming where dimensional accuracy of the electroformed part and its performance may be affected by stress. For example, the nickel deposited on a silver-coated vinyl plate used in the electrotyping industry must have low internal stress; otherwise the nickel will lift and break the relatively weak bond between the silver film and the vinyl base. For reasons such as this it is often specified that the stress present in electroplated coatings be low and compressive in nature.

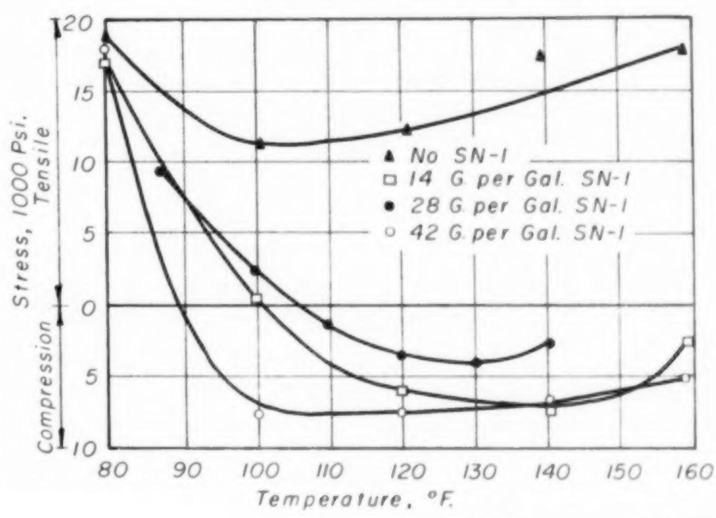
The spiral contractometer described by A. Brenner and S. Senderoff (*Proceedings* of the American Electroplaters' Society, Vol. 35, 1948) was used for stress measurements, and the results reported in this article are for a nickel thickness of 0.0006 in. (1-g. deposit on a 65.1-sq.cm. surface). The stresses in nickel deposits from the sulphamate solution have been reported to be low and this is borne out by the data reported here. The object, however, was primarily to obtain stresses in the compressive direction so as to provide a coating suitable for most commercial applications. This led to the study of organic addition agents which would impart this property, culminating in the selection of a formulation based on naphthalene trisulphonic acid compounds and known as SN-1.*

The effect of current density on deposit stress at 100° F. is shown in Fig. 5. Deposits from the sulphamate bath without the addition agent exhibit tensile stress throughout, the stress increasing with current density. With 42 g. of SN-1 per gal. of solution, the stress is compressive up to 100 amp. per sq.ft., while with only 14 g. of the addition agent present the stress becomes tensile at approximately 40 amp. per sq.ft. Figure 6 shows the effect of current density on the stress of nickel deposits from a bath containing 28 g. of SN-1 per gal. of solution which was operated at various temperatures. It indicates that, in general, an increase in temperature will keep the deposit in compressive stress. The effect of temperature on stress of nickel deposits from the sulphamate bath containing various amounts of SN-1 is shown in Fig. 7 for 40 amp. per sq.ft. An increase in temperature produces a compressive stress, except in the straight sulphamate solution.

Although the study of the effect of the pH on stress is not complete, enough evidence has been gathered to show that deposits from the sulphamate bath behave in a manner similar to those from a Watts-type nickel bath. The stress at pH 3.5 with and without SN-1 was found to be

*Available commercially from Hanson-Van Winkle-Munning Co.

Fig. 7 – Effect of Temperature on Stress in Deposits Obtained at Current Densities of 40 Amp. per Sq.Ft.



-7.6×10^3 and 12.1×10^3 psi., respectively. At a pH of 5.5 these values were -0.7×10^3 and 20.2×10^3 psi.

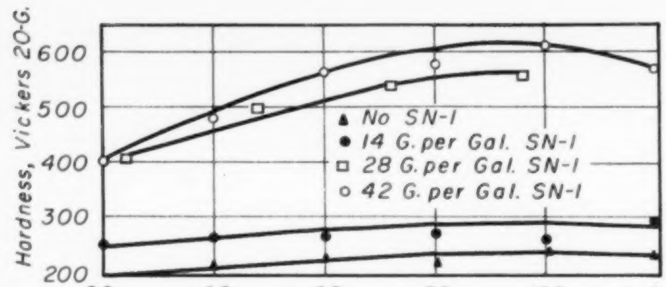


Fig. 9 – Effect of Current Density on Hardness of Deposit From Baths at 120° F.

Hardness – Hard deposits are needed in many electroforming operations, as for building up of worn parts or for electrotypes where long press runs are made. The straight sulphamate nickel deposits are relatively soft and this was the second reason for selecting an organic addition agent for use in the bath. The effect of bath temperature on the hardness of the deposits obtained from a bath containing various amounts of SN-1 and operated at 60 amp. per sq.ft. is shown in Fig. 8, while Fig. 9 shows that when the bath is at 120° F., this being the temperature having the strongest effect in raising the hardness of the deposit, the hardness increases with increasing current density up to 100 amp. per sq. ft.

Samples prepared for hardness determination were plated on tin-plate stock, stripped, mounted and metallographically polished prior to testing. A Vickers micro diamond indenter was used and each value reported represents the average of 3 to 5 penetrations. Each determination was made on the cross section of a deposit 0.001 in. thick, rather than on the face next to the tin plate or on the final layer deposited.

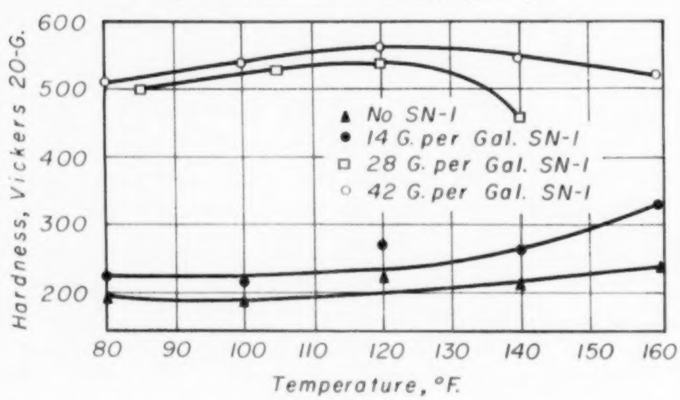
The pH of the operating bath influences the hardness of the coatings deposited from it. Values obtained showed an increase in Vickers hardness from 574 to 646 for pH values of 3.5 and 5.5, respectively, with the addition agent present; with the straight sulphamate solution, the hardnesses were 189 and 276 for pH 3.5 and 5.5, respectively.

Tensile Strength and Elongation – Tensile strength measurements of the sulphamate deposit with and without SN-1 showed that the addition agent increases the tensile strength considerably (see Table II). With sound deposits, a parallel exists between hardness and tensile strength of nickel deposits; as the hardness of the deposit increases, tensile strength also increases and elongation decreases.

Electrical Resistivity – The resistivity of a deposit is affected by the co-deposition or inclusion of either inorganic or organic materials and by the general soundness of the structure. The resistivity values reported in Table III were determined by comparing the potential drop across a deposit of known dimensions with that across a standard 0.001-ohm resistance in a series circuit. The measurements were taken at room temperature with all values recalculated to a temperature of 77° F. (25° C.).

Deposits with high electrical resistance required in one military electroforming application were obtained by co-depositing cobalt chloride and the organic addition agent (Table III). This combination increased the resistivity almost two-fold and brought it into the range desired.

Fig. 8 – Effect of Temperature on Hardness of Deposits Obtained at 60 Amp. per Sq.Ft.



Applications

Deposits from nickel sulphamate solutions have found applications in three fields: (*a*) resizing of worn or badly machined parts, (*b*) heavy coatings for variout purposes, and (*c*) electroforming.

Table II – Effect of Addition Agent (SN-1) on Properties of Deposits

SN-1 G./Gal.	Current Density Amp./Sq.Ft.	Temp. °F.	Tensile Strength	Elong. in 2 In.
0	60	85	94,000	5.0%
0	60	120	108,000	4.5
0	60	140	98,000	3.25
28	60	120	155,000	—

As the hardness of these deposits approaches Vickers 600, poorly machined and worn parts may be salvaged by this process. To salvage tools, crankshafts, diesel cylinder liners, and similar items that are expensive to produce, the usual procedure is to heavily chromium plate and then grind or lap the surface to specified dimensions. The applied thickness may be as high as 0.030 to 0.050 in. Although hard, deposits of this thickness produced from other types of baths generally have high internal stress, which may lead to somewhat unsatisfactory service. By employing the hard nickel deposits from the sulphamate bath for a major portion of the build-up, the service life actually may be improved and occasionally the entire thickness of chromium may be replaced with this hard nickel deposit.

Because the nickel deposit from the sulphamate solution has a low tensile or compressive internal stress, and because the hardness of the deposit can be varied during the electrolysis period, it has many applications for the coating of both conductive and nonconductive surfaces. For example, these qualities are desirable for increasing the press life of both stereotype and electrotype printing plates. The low internal stress insures intimate contact, with little tendency to curl or lift when applied to base materials where the inherent adhesion is poor. An equally important factor contributing to long runs of quality printing is that, although hard, the deposit is not brittle. In comparison with deposits from sulphate solutions customarily used in the graphic arts industry, the use of sulphamate nickel coatings has increased press runs by 50% in smooth-stock magazine printing and approximately 35% in carton printing where rough paper stock greatly accelerates plate wear.

Deposits from the modified sulphamate bath have found applications on various aircraft parts where fatigue values are critical and where an initial soft coating with a hard case is beneficial. For some applications a low compressive stress is essential on parts subjected in service to high impact; deposits with tensile stress would quickly fail.

Electroforming

Electroforming, which is the manufacturing or reproduction of articles by the electrodeposition of metals on matrices or patterns, is an important application for the sulphamate nickel plating process.

Aside from the electrotype plates for printing mentioned above, its first use was the electroforming of stampers for the phonograph record industry. The low tensile and compressive stress characteristics of the deposit, hardness and resistance to wear are all favorable for this application. The fabrication of stampers is accomplished by electrodepositing either nickel, copper or iron against a nickel surface passivated in a sodium dichromate solution which enables the plated part to be separated from the original. If the deposit has a high tensile stress, the electroformed part will separate prematurely around the outside areas of the master. If the deposit has a high compressive stress, this premature separation will take place in the center of the stamper; therefore, the control of stress characteristics of the deposit is extremely important in the manufacture of such articles as this.

Recently, this process has been used in manufacturing geometric surface roughness standards. These standards were developed jointly by General Motors Corp. and Chrysler Corp. and are now being electroformed commercially. Other applications for the sulphamate bath include leather embossing dies, electroforming of various types of tubing, such as used in radar equipment, and aviation devices that require definite electrical resistivity properties.

Table III – Resistivity of Nickel Sulphamate Electrodeposits

Additions, G./Gal.		Temp. °F.	Current Density Amp./Sq.Ft.	Resistivity Micro-Ohm-Cm.
SN-1	$CoCl_2$			
0.0	0.0	140	40	8.6
28	—	110	40	9.9
—	7.	110	60	9.8
42	—	140	40	10.7
28	12	140	40	16.3

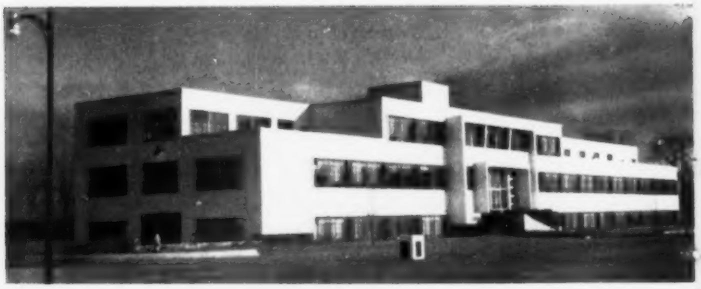


Fig. 1 –(Right) Aerial View of the Ottawa Laboratories of the National Research Council. Applied Chemistry Building, where most of the metallurgical research is carried on, (upper left in aerial view) is shown above

Research in Canada

*By HAROLD J. ROAST**

Government-sponsored scientific research in Canada is a \$35,000,000 business carried on by the National Research Council in 15 large and modern buildings by a staff of 2000. Varied metallurgical projects, both scientific and practical, are pursued.

EARLY last summer the National Research Council of Canada held open house at its laboratories in Ottawa, giving friends and guests an opportunity to inspect one of the largest aggregates of diversified scientific research in the world. The Council's annual expenditure is in the neighborhood of \$15 million, present capital investment is more than \$35 million, and a staff of 2000 works in 15 large and modern buildings standing in 400 acres.

Typical of the scientific investigations being carried on in the metallurgical department are the preparation of sapphire and ruby crystals by the Verneuil burner technique, measurements of the magnetic susceptibility of silver and copper-base alloys and preliminary work on the mathematical techniques necessary for calculating the Hartree self-consistent field of the monovalent gold ion. In the preparation of silver catalysts for the oxidation of ethylene, a method has been found whereby silver can be coated with calcium directly.

Two examples of more practical projects are an improved method for the production of zirconium and the production of high-purity ingots of germanium. The zirconium project is part of a program organized by Prof. L. M. Pidgeon of the University of Toronto. It is based on the Kroll process, with some modifications aimed at simplifying the small-scale apparatus and pos-

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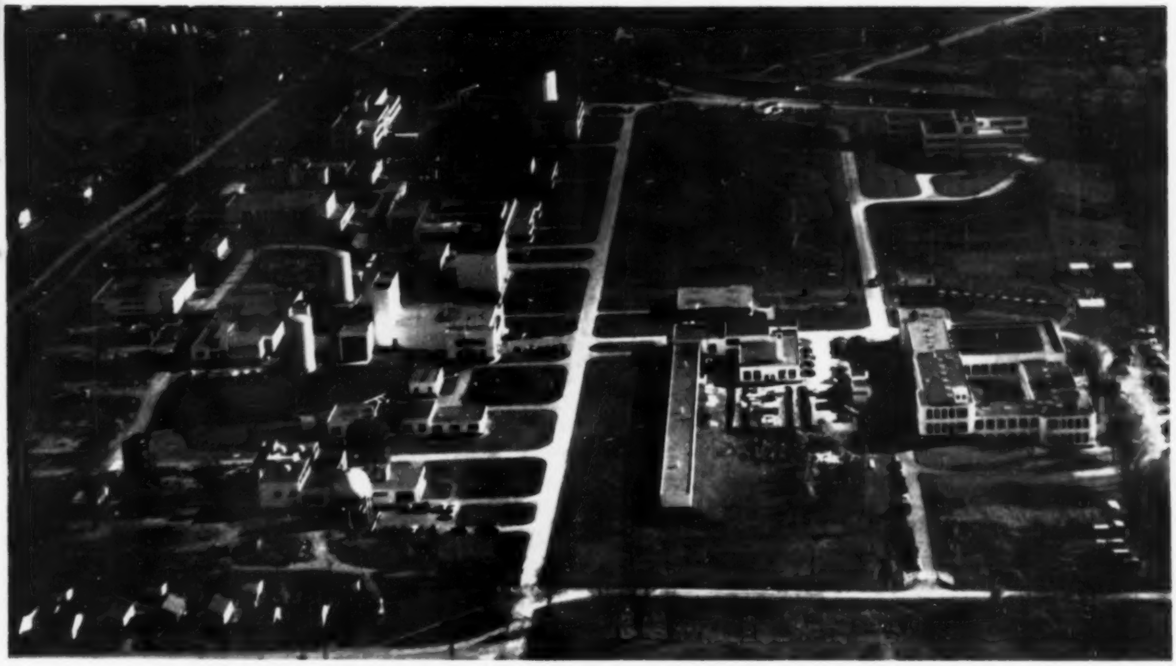


sibly improving the product. Zirconium sponge is produced, about 5 to 6 lb. per run, with an average oxygen content of less than 0.1% and a hardness of about Rockwell A-46. This metal is of particular interest as a structural material for nuclear reactors.

The second item was undertaken in co-operation with the Radio-Electrical Engineering Division to supply high-purity germanium for electrical property measurements needed to supply the ever-increasing demands for transistors. For these tiny precision elements, the metal must be purified to a maximum of one foreign atom to each 100 million germanium atoms. As little as one part of impurity in 10 million leaves the germanium too highly conductive for transistor purposes.

Purification is done by "zone melting", which depends on the fact that the impurities "prefer" molten metal to solid metal. Progressive melting of a small bar of germanium drives the impurities to the end of the bar, which is then cut off and the process repeated until only one part in a billion of impurity is present. This, however, is too pure for the purpose and so a controlled amount of material is added at the next stage. The germanium at this point is polycrystalline. To obtain the desired single crystal, the metal is melted in a special furnace (Fig. 2). A small "seed" crystal of germanium is dipped in the molten metal and slowly lifted. The germanium freezes to the seed and after several hours of slow motion a long single crystal is formed which provides enough germanium for several thousand transistors.

Administration—All the laboratories are under the general direction of the advisory body of the National Research Council which is at present composed of 21 members, responsible to a committee of seven cabinet ministers. The advisory council has final control of all grants and scholarships, but is responsible for broad policy only in the operation of the laboratories. There are eight laboratory divisions and two regional institutions – the Prairie Regional Laboratory in Saskatoon and the Maritime Regional Laboratory in Halifax. The divisions in Ottawa cover applied chemistry, pure chemistry, physics, applied biology, medical research, mechanical engineering (including aeronautics), radio and electrical engineering, and building research. Most metallurgical research is carried on in the Applied Chemistry Building. The building research division follows many angles that do not appear to be directly associated with the erection of structures. For instance, corrosion is studied

with special reference to domestic hot water tanks and their reaction to the various waters found in many parts of Canada. There is a soil mechanics section, and a snow research section. The titles of the other divisions mentioned above speak for themselves.

The main objective of the National Research Council is to stimulate all phases of applied and fundamental research in Canada and to link science with industry. How this is done can be illustrated by a typical request sent in by the Canadian Arsenals Limited. In modern ammunition, it is imperative that certain safety features are not by some mischance left out of a completed component, yet it is not easy to check the whole assembly to determine whether the safety device is included. In certain ammunition the safety feature hinges on the presence of a tiny copper ball which prevents a backward blast which might injure the gun crew or damage the gun. X-ray inspection will tell the story but it is costly and time-consuming, especially on a production line.

N.R.C. solved the problem by what is believed to be the first instance in history where mass-production items have been "pre-cooked" in an atomic pile. The copper balls were exposed to radiation at the Chalk River nuclear reactor. The radioactivity of copper is very short, but there is a small amount of silver in the copper used which could induce a small amount of temporary radioactivity – enough for the purpose but safe for human handling. The components to be tested are carried by conveyer belt over a detector developed by the National Research Council, which passes those components that contain the safety ball (as evidenced by radiation) and rejects any that do not. Should the detector itself fail to work the operation stops until adjustments are made.

Another important part of the work of the Council is the administration of a system of grants and scholarships to stimulate research in the universities, and to provide students with post-graduate help. Some $2,000,000 annually is distributed.

A division of administration is responsible for general services, personnel, distribution of scientific journals, and awards. Other services include the library unit, and liaison offices in Ottawa, Washington and London which are responsible for informing the researchers as well as Canadian industry in general about new technical developments. Field officers of N.R.C. are stationed in

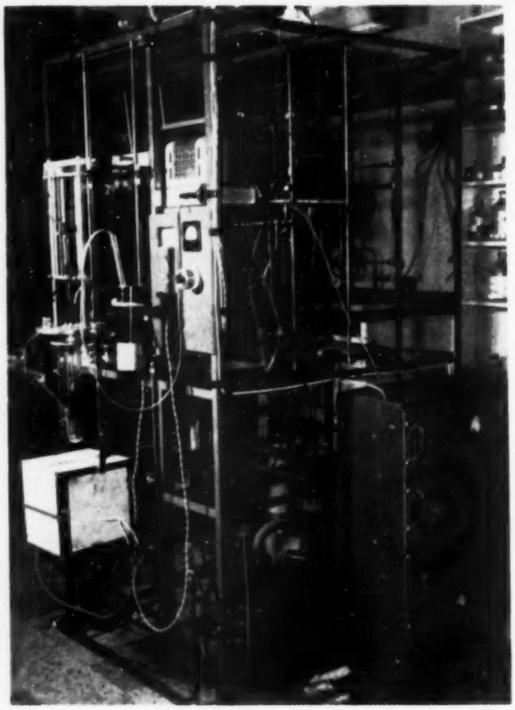


Fig. 2 – Apparatus for the Production of Germanium Single Crystals

the principal manufacturing districts. The patent section cooperates with Canadian Patents and Development Limited, a Crown corporation which arranges licensing of patents on inventions originating in the N.R.C. laboratories, as well as other agencies. Profits from licensing arrangements are assigned to the Council for further research and development.

The ever-increasing number of inquiries from large and small industries attests to the success of the N.R.C. in bringing research and industry together. This does not mean that industry is discouraged from developing its own research organization; on the contrary it is urged to do so. If the industrial problem is of national concern the N.R.C. bears all the cost; if it rates something less than this the cost may be divided between industry and the Council; when the problem is of special interest to one company and no facilities are available elsewhere in Canada, the N.R.C. may undertake the research on a fee basis, and the results become the property of the company.

All this adds up to a very healthy scientific contribution to the allied cause.

Skin Milling by Chemical Solution

By *MANUEL C. SANZ**

Hot alkaline baths under adequate control can dissolve aluminum alloys at uniform rates and at such speeds as to compete with skin milling, and to open new avenues in airframe construction and parts design.

IT IS WELL KNOWN that manufacturers of airframes go to extraordinary lengths to eliminate useless weight from their structures. This has always been true. Perhaps this has received more emphasis since we have been required to build very large or very fast craft or those with maximum ceiling or flying range – even those where all these requirements are set. For these it has frequently been necessary to machine long members of varying cross sections, or even to taper-mill wide sheets so they will be thick along one edge and thin along another. For this, very large and expensive machinery is necessary.

During the experimental development of a welded part in North American's aerophysics department, it was necessary to reinforce or thicken the metal along the joint. The sheet was Alclad 2024-T3 (24S-T3) with 60,000 psi. tensile strength. Heliarc welded joints broke alongside the weld at about 45,000 psi. The problem was to increase the thickness at the weld somewhat more than 33% so the joint would be stronger than the sheet. The situation is shown in Fig. 1.

A large skin mill could of course thin the sheet as required, but some thought was given to suitable and less costly alternatives, leading to the idea that the surplus metal could be eaten away chemically by a process of deep etching. Later studies have developed a thoroughly practicable process of this sort which has been named "chem-milling". The sheet was partially masked with a chemically resistant coating and submerged in a hot alkaline solution which removed metal in the unmasked areas. Commercial success has resulted because there are now available (*a*) new organic coatings and tapes resistant to hot alkaline solutions, (*b*) compounded or modified etching solutions which etch uniformly and without changing the physical or chemical properties of the remaining metal, and (*c*) perfected measuring and controlling equipment (electronic).

Fig. 1 – Design of Welded Joint Equal in Tensile Strength to Adjoining Sheet

The chemical composition of the solution (based on strong alkalinity) is enhanced by additions to produce smoother surfaces, more uniform action, better wetting, and easier disposal of byproducts. The reaction is exothermic, and hydrogen and alumina result.

Masking Devices

Various methods have been studied for masking those portions of the aluminum sheet, forging, or extrusion which are to retain their original thickness. In order of greatest economy they are:

1. **Templets** may be used for parts which have no cross ribs or stiffeners. The tooling consists of a pattern plate and a rubber seal, both of which have the design cut out; a base plate; and metal gaskets, as illustrated in Fig. 2. Masking panels or templets may be held with clamps, bolts, or by vacuum; they may also be used with parts of simple curvatures. Obviously, they must be made of materials unaffected by the etching solution. The economy of this method results from its simplicity – that is, there is no need for spray painting, baking, or removing any masking compound after etching.

*Group Leader, Materials Research and Process Dept., North American Aviation, Inc., Downey, Calif.

2. **Adhesive tapes** are satisfactory where it is necessary to chem-mill to different depths in one panel, inasmuch as the tape can be easily stripped off progressively after etching has been started on the deepest sections (see Fig. 3). Tape may also be used to protect any coating during handling in or out of the tank.

3. **Paints,** chemically resistant, may be sprayed or brushed on. Templets are of course necessary. Flexible ones will serve for contoured panels for sandwich construction like the ones in Fig. 4 (although such items must be of such size as to fit the etching tanks).

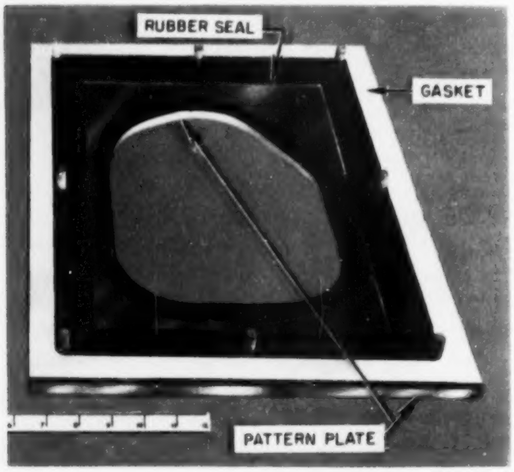
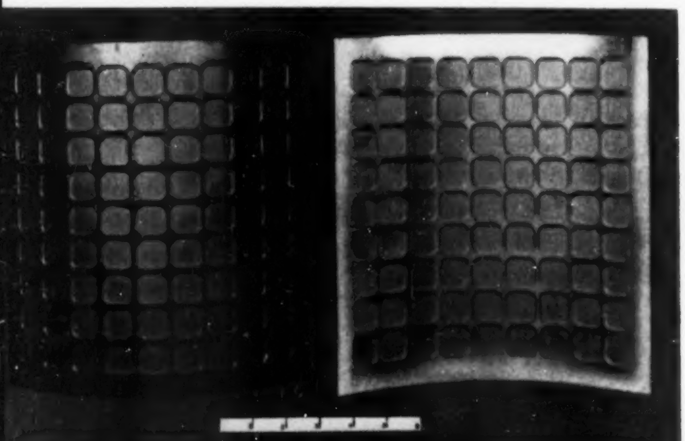


Fig. 2 – Templet or Mechanical Masking Tool. The sheet to be etched is laid over the pattern plate and a stiff base plate bolted down. Openings in the pattern plate locate areas for "chem-milling"

Fig. 3 – Panel "Step-Etched" After Masking With Tape. The 0.032-in. areas were bare; the tape on the 0.040-in. area was removed early in the process, and the tape on the 0.076-in. areas at half time. Edges were masked at all times

Fig. 4 – Contoured Panels, Matched for use in Sandwich Construction



Other methods which clearly are applicable are the silk-screen process, photosensitive organic coatings, and preferential electroplating.

Controls

The amount of metal removed during chem-milling is determined while the part is in the tank, and it is removed when the proper gage thicknesses are reached. The simplest method, although not suitable for plant operation, is to remove the part at intervals and measure the thickness. Another device used in the experiments is to immerse a small sample of the same thickness and measure it at various intervals.

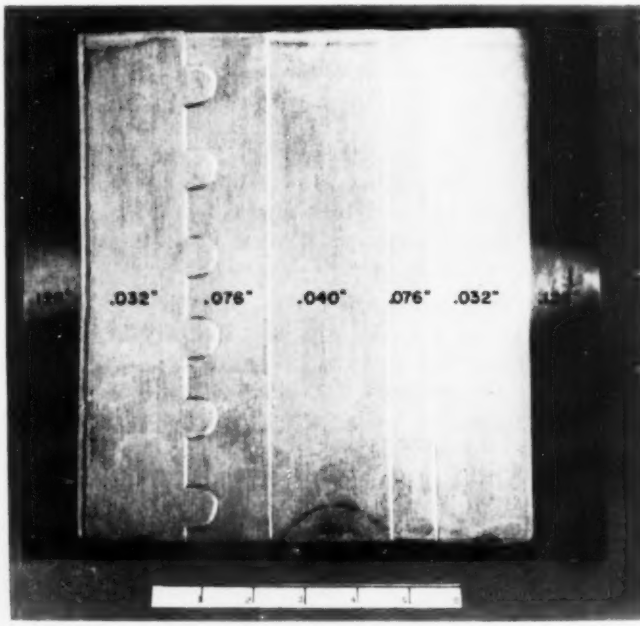
More reliable and accurate controls have been constructed for factory operation. These are based upon circuits that ring an alarm and trigger a mechanism to remove the sheet from the tank when the desired depth has been obtained.

Other devices are being developed to control the rate of immersion into the etching tank to obtain an accurately tapered part.

Another electronic control has also been designed to regulate the etching rate and adjust the chemical concentration in the solution.

Properties of Chem-Milled Metal

Aluminum parts have been etched in process without known detrimental effects, for such purposes as cleaning before welding, cleaning of forgings after heat treatment, and for decorative



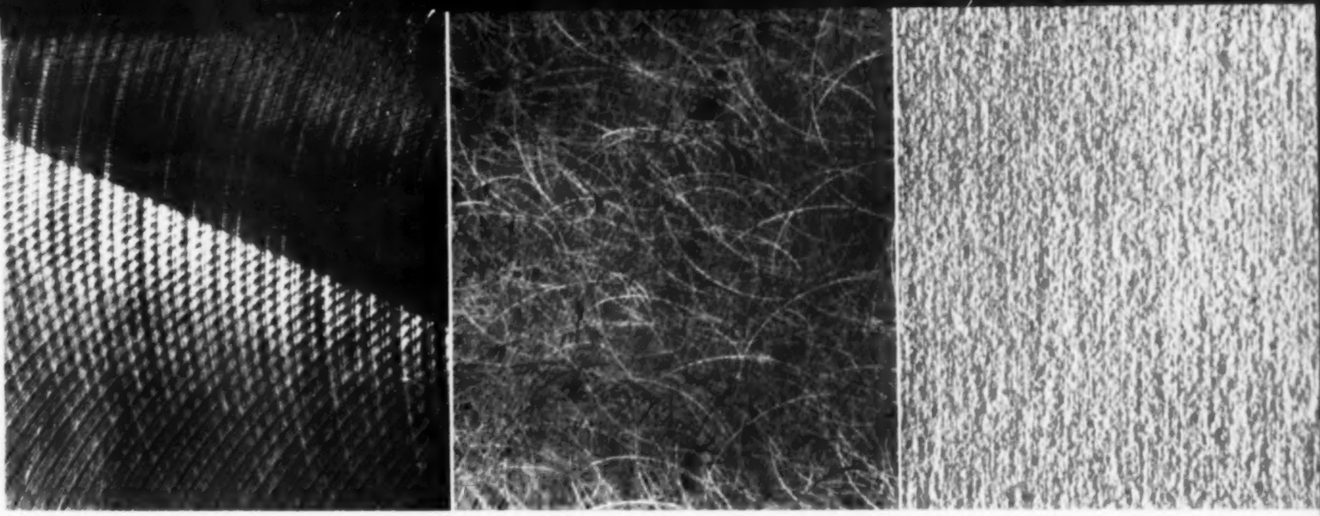


Fig. 5 – Representative Surfaces, Magnified Five Times. Left is machine-milled; center is machine-milled and polished; right is chem-milled

purposes. This experience would imply that the chemical, physical, and mechanical properties are unchanged. Results of tests to date made on chem-milled parts confirm the above indication.

The finished parts require no further work such as sanding and polishing. Roughness of etched surfaces is on the order of 50 to 60 micro-inches. Figure 5 compares machine milled, milled and polished, and chem-milled surfaces. Careful microscopic examination finds no chemical attack at grain boundaries and no change in chemical composition at the surface.

Bend and Fatigue Tests – The type of etchant has a marked influence on bend and fatigue test results. Improperly formulated etchants leave rough surfaces, which in turn lower the fatigue limit or bend radius. Proper etchants produce parts meeting engineering specifications for minimum bend – that is, radius of 3t for 0.032 to 0.068-in. thickness. At a bend radius of 2t, which test exceeds the requirements of most engineering standards, the machine-milled sheet showed better characteristics.

Flexural fatigue tests conducted on parent, chem-milled, and machine milled aluminum sheets at stresses of 38,000 and 48,000 psi. indicate that the chem-milled specimens are comparable to the parent and slightly better than the machine milled specimens at the 48,000-psi. stress level. Test data are shown in Fig. 6 where each plotted point represents the average of ten specimens. The differences are so small as to be hardly significant.

Tensile tests on the etched clad 2024 (24S) sample show increased strength, as would be expected due to the removal of the lower-strength cladding on one side of the specimen.

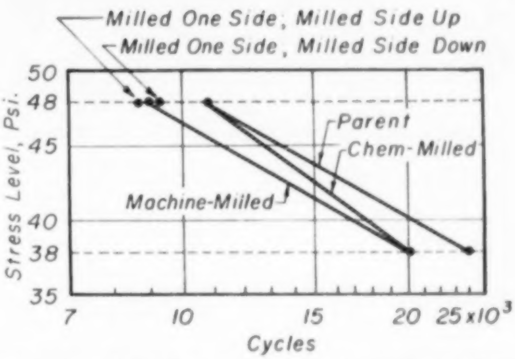


Fig. 6 – Flexural Fatigue Tests (Averages for Ten Specimens) Show no Significant Differences Between Chem-Milled and Machine-Milled Specimens

Specimen	Gage	Ultimate	Elongation
Parent	0.125 in.	60,000 psi.	12.4%
Etched	0.035	61,700	14.7

Corrosion – No extensive corrosion tests have yet been run. Since microstructural examinations have never shown any intercrystalline attack, no change in the resistance to natural environments is anticipated.

Chem-milling, however, offers an easy means for corrosion protection. If machine milled areas must receive a chemical treatment, the unmilled areas of clad sheets must be masked to protect them from surface treatments, which might interfere with welding. In the chem-milling process, however, such areas are already masked; the parts requiring surface treatment go directly into the surface treating tank.

Advantages and Disadvantages

Engineering Design Advantages – Chem-milling can be performed *after* forming operations whereas machining is extremely difficult and limited to very slightly contoured parts.

Chem-milling is not limited by shape, direc-

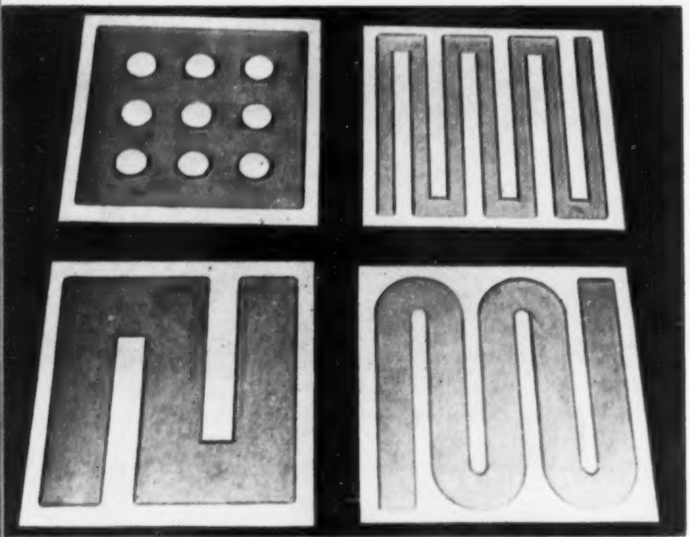


Fig. 7 – Heater Panels of Various Designs Show Adaptability of Chem-Milling to Complex Shapes and Comparatively Sharp Corners

tion of cut, or limiting radius of cutters. Complex shapes, broad or narrow cuts, and comparatively sharp corners may be made in one operation, as indicated by the heater panels shown in Fig. 7. The same applies to aircraft forgings (as described in the August issue, p. 88, by A. H. Petersen) with webs which must be thinned beyond the limits of die pressing or removed entirely.

Chem-milling can be done on either or both sides of a sheet simultaneously. Machine cutting on one side at a time usually warps the part.

Light-weight designs of unconventional nature appear possible. Sandwich construction (Fig. 4) appears more feasible, since heavy "lands" can be left on a panel wherever attachments are to be made. Stiffeners can be produced integrally with the skin.

The process also permits tapering of sheets, extrusions, hat sections, and other parts suitable as stiffeners, to transfer design stresses proportionally as required.

Economic Advantages – Chem-milling lends itself to automation and labor saving. No highly skilled operators are required. The basic equipment is already available in the plating industry.

The number of parts that can be etched simultaneously is limited only by the size of the tanks, thus offering tremendous manufacturing relief. This will be mentioned again, later in this article.

No sanding or polishing – either by machine or by hand – is necessary on chem-milled areas.

Costs–First designs have been made for a complete department, based on a time schedule for one class of parts otherwise requiring three milling machines costing about \$200,000 apiece, as installed. Preliminary cleaning, prior to masking, is to be done in equipment already installed and consists of the following line of tanks:

1. Solvent degreaser (180° F.)
2. Hot alkaline cleaner (180° F.)
3. Cold water rinse
4. Chromic acid dip
5. Hot water rinse (180° F.).

From here the cleaned parts go to a preparation area, consisting of tables where the masking may be done, a paint spray booth and a drying oven. Thence the routing is through a new series of tanks, as follows:

6. Alkaline etching tanks
7. Cold water rinse
8. Smut removal
9. Masking removal (some hand work)
10. Final hot water rinse (180° F.).

It is estimated that the cost of the line, from No. 6 to No. 10 will be about \$30,000. Space required will be about 5000 sq. ft.

Costs of metal removed, with no credit for byproducts, vary with the method of masking. If no masking is required (as in the manufacture of tapered sections) the cost per pound of aluminum removed is \$0.27. This is based on a cost of \$0.18 per lb. of etchant. Machine milling costs at least \$1.00 per lb.

When parts must be mechanically masked, the cost is increased by the labor of clamping and unclamping, plus part of the cost of the fixtures (which, by the way, have a very long life).

Tape and paint spray are next higher in cost. They are used only for parts of intricate design not economically machinable. A survey of chem-milling by spray masking versus machine milling of a production part showed \$9.36 for chem-milling as against \$25.00 for machine milling performed in North American Aviation's plant and \$80.00 per part in 60 to 150-part lots for machine milling by a subcontractor.

Conclusions

The limitations and the future possibilities of this new chem-milling process remain to be determined. It promises to replace machine milling of many types of parts since it has been found to be faster and considerably cheaper. It also offers new design possibilities.

At present one pilot plant is in operation and a production facility is being planned.

Correspondence . . .

Concerning the Endurance Limit of Zirconium

PITTSBURGH

In the April 1954 issue of *Metal Progress*, an item was published in the correspondence section that referred to the endurance limit of zirconium. The reported results may be applicable to a material which is cold worked an unknown amount, as was pointed out by the authors. However, the reported data are misleading, especially so since most of the low-stress specimens did not break within the limits of the gage section.

Extensive work on the fatigue properties of zirconium and some zirconium alloys has been carried on at Westinghouse Atomic Power Div. and a summary report is to be published in the near future. A few results from room-temperature fatigue tests of annealed unalloyed zirconium are as follows:

Yield strength (0.2%)	16,700 psi.
Tensile strength	33,300 psi.
Elongation in 3 in.	20%
Reduction in area	33%
Hardness, Vickers (30 kg.)	88
Endurance limit, unnotched*	21,000 psi.
Endurance limit, notched*	8,000 psi.
(K_t) Stress concentration factor	3.5
Fatigue ratio [1]	0.63
(K_f) Strength reduction factor [2]	
at 10^6 cycles	1.4
at endurance limit*	2.6
Notch sensitivity index [3]	0.64

* 10^7 cycles

[1] Ratio for unnotched endurance limit to tensile strength.

[2] Ratio of unnotched fatigue strength to notched fatigue strength

[3] Notch sensitivity index, $q = \dfrac{K_f - 1}{K_t - 1}$

F. FORSCHER and J. J. KEARNS
Atomic Power Division
Westinghouse Electric Corp.

Barn Now Too Long

Let's get this straight, and shake the whammy. In Pahler's article in April 1954, footnote on p. 87, we said that a barn is 10^{24} sq.cm. Lt. Com. Burpo in the August 1954 issue, p. 123, told our readers that a minus sign had been dropped from the exponent, but the whammy persisted and the sq. was dropped, making a barn a distance rather than an area. Let us now quote from National Research Council's "Glossary of Nuclear Energy Terms", and hope that it gets into print correctly:

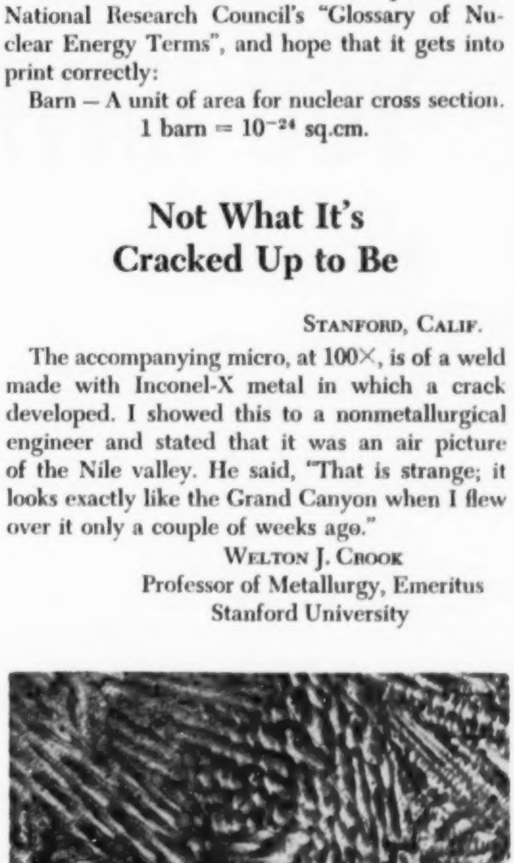
Barn — A unit of area for nuclear cross section.
1 barn = 10^{-24} sq.cm.

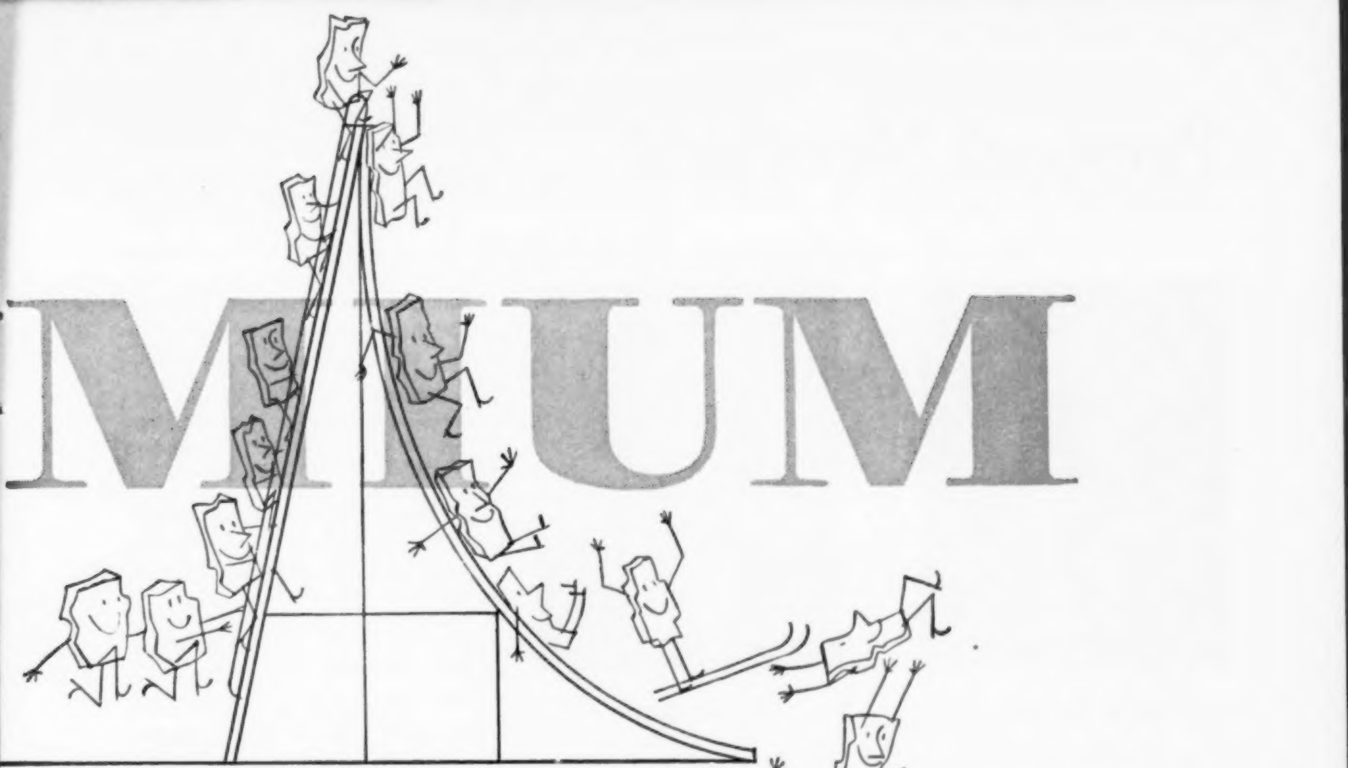
Not What It's Cracked Up to Be

STANFORD, CALIF.

The accompanying micro, at 100×, is of a weld made with Inconel-X metal in which a crack developed. I showed this to a nonmetallurgical engineer and stated that it was an air picture of the Nile valley. He said, "That is strange; it looks exactly like the Grand Canyon when I flew over it only a couple of weeks ago."

WELTON J. CROOK
Professor of Metallurgy, Emeritus
Stanford University





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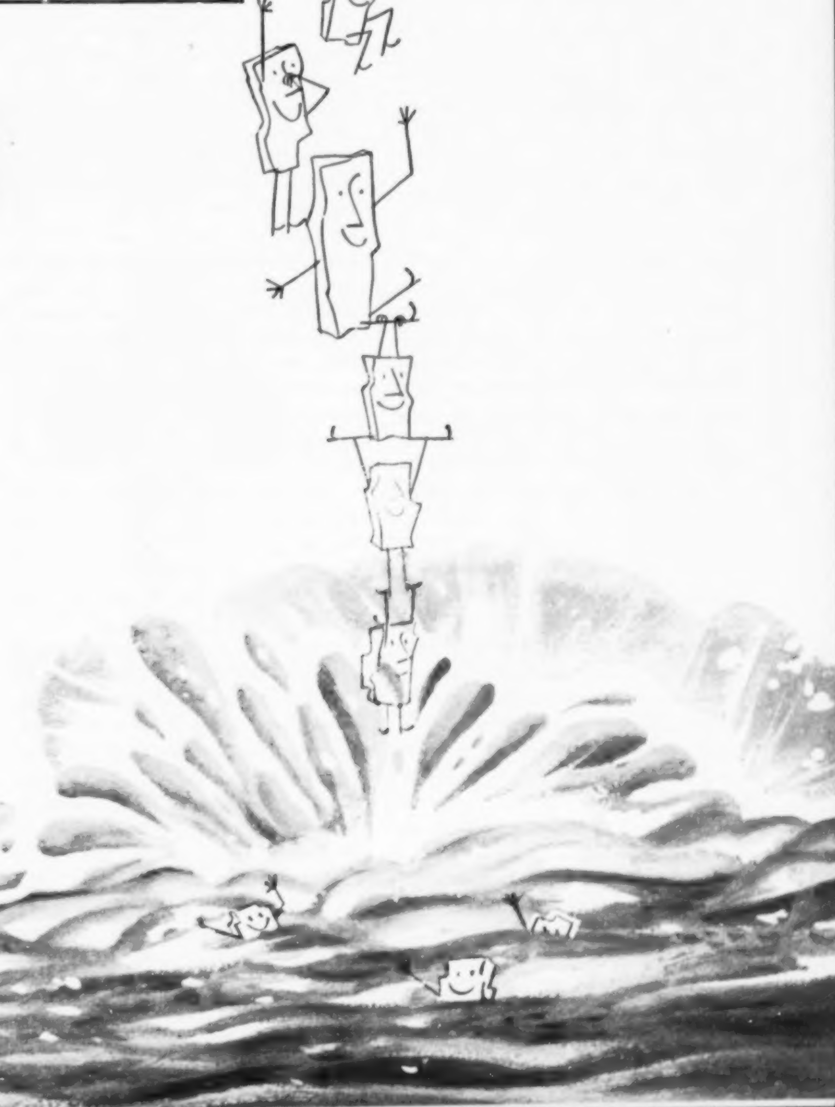
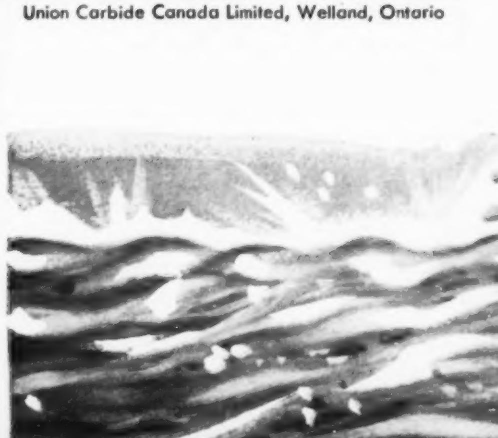
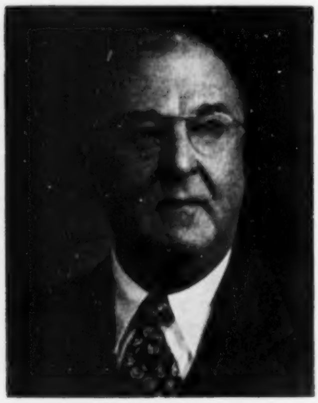




Personal Mention



Geoffrey M. Rollason

Max W. Lightner

G. M. Rollason, general manager of the die castings division of Aluminum Co. of America, has retired after 35 years with the company. An Australian with a Bachelor of Science degree from Melbourne University in 1910, Mr. Rollason came to this country and enrolled at M. I. T., where he received a degree in chemical engineering in 1913. After a few years with the New Jersey Zinc Co. and an army term, he joined Alcoa in 1919 as a research engineer at Cleveland. Eight months later he was named assistant director of research, and in 1920 was appointed manager of the Cleveland foundry. In 1922 he became manager of the Detroit Works, and the following year was transferred to Garwood, N.J., where he later became vice-president, director and then president of the Aluminum Die Casting Corp., a former Alcoa subsidiary. In 1928 he became plant superintendent and later vice-president of the United States Aluminum Co., now an inactive subsidiary. He was named manager of Alcoa's die castings division in 1933. Long a leader in the light-metal fabricating industries, Mr. Rollason is currently serving as president of the American Die Casting Institute. In World War II he served on the Die Casting Advisory Committee to the War Production Board.

Two members were involved in U.S. Steel Corp.'s recent reorganization of technical personnel into three research groups. Named as assistant vice-presidents were James B. Austin, head of U.S. Steel's research laboratory in Kearny, N. J., whose field will be fundamental research; Max W. Lightner, manager of research and development, whose field will be applied research and development; and Robert W. Holman, assistant superintendent of the Gary sheet and tin mill, whose field will be operations research. A biographical appreciation of Dr. Austin, currently national president of, was published in *Metal Progress* for February 1954.

Max Lightner has been with the group continuously since 1933, with the exception of two years when he served as vice-president of operations and director of research for Heppenstall-Eddystone Corp. He is a graduate of Pennsylvania State College (1929) and received his Master's degree at Carnegie Tech., where he served as research engineer for the Metallurgical Advisory Board from 1930 to 1933. Mr. Lightner started with U.S. Steel as assistant to chief metallurgist, Homestead District Works (then Carnegie-Illinois Steel Corp.), and held various positions leading to manager of research and development for the entire corporation in 1951. He is a past chairman of the Pittsburgh Chapter, and received the David Ford McFarland award of the Penn State Chapter in 1950. He is a member of the Committee on Ship Steel of the U.S. Navy, of the American Iron and Steel Institute, and the American Institute of Mining and Metallurgical Engineers.

Alexander Konzan has accepted a position as chief metallurgist at Joy Mfg. Co., Claremont, N. H.

Edward J. Ramaley, formerly in manufacturing research at Lockheed Aircraft Corp., Burbank, Calif., is now employed as a tool engineer in the tool development group of North American Aviation, Inc., Columbus, Ohio.

G. S. Sangdahl, until recently associated with the metals research laboratory at Case Institute of Technology while studying for advanced degrees, has joined Chicago Bridge & Iron Co., Birmingham, Ala., as metallurgical engineer.

Robert C. Mann, after ten years at Hanford Works at Richland, Wash., with E. I. du Pont de Nemours & Co. and General Electric Co., has transferred to Idaho Falls, Idaho, as supervisor, instrumentation and controls, for the Aircraft Nuclear Propulsion Project.

John B. Fetherlin has returned to the Duquesne, Pa., works of United States Steel Corp. after spending 14 months at the research laboratory at Kearny, N. J. His position has been changed from process metallurgist to supervisor of physical metallurgy.

S. S. Rice, formerly chief metallurgist of the Massillon, Ohio, division of Ekco Products Co., has been transferred to the main offices of the company in Chicago, where he is assistant to the manufacturing vice-president.

Peter J. Provias, formerly foundry metallurgist and supervisor for the Cockshutt Farm Equipment Co., Ltd., Toronto, Ont., is now a metallurgical engineer with the development and research division of International Nickel Co. of Canada.

Personals

A. B. Kinzel, who has been associated with Electro Metallurgical Co. and its research in metals and ferro-alloys since 1917, has been made director of research for the seven major laboratories of the parent corporation, Union Carbide and Carbon Corp. A biographical appreciation of Dr. Kinzel appeared in *Metal Progress* in August, 1953.

Jack G. Allen has been elected president, general manager and a director of Artisan Metal Works Co., Cleveland. Mr. Allen has most recently been vice-president and general sales manager of the Bingham-Herbrand Corp., Fremont, Ohio. Prior to this position he was vice-president of Plomb Tool Co., Los Angeles, and concurrently held the same position with Plomb affiliated companies, as well as being director of all foreign operations of the company and its subsidiaries.

Spencer H. Bush is now in charge of physical metallurgy research in the applied research subsection, engineering department, of General Electric Co.'s Hanford Atomic Products Operation for the Atomic Energy Commission near Richland, Wash. Mr. Bush was formerly a metallurgist in the atomic research subsection assigned to pile metallurgy problems.

M. E. Cummings has resigned his duties as assistant vice-president of operations of Crucible Steel Co. of America, Pittsburgh, to take over the directorship of the company's new toolsteel research division at the Sanderson-Halcomb Works, Syracuse, N.Y. Other members of the research staff are **Robert F. Spillett**, **J. Robert Richards**, and **Robert B. Ganley**.

D. E. Knight has joined the general sales department of Haynes Stellite Co., a division of Union Carbide and Carbon Corp., in Kokomo, Ind., and will be concerned primarily with development work on hard facing materials. Mr. Knight was production methods engineer at Curtiss-Wright Propeller Div., Caldwell, N. J., from 1941 to 1946, after which he joined Linde Air Products Co., another division of Union Carbide and Carbon Corp., as service engineer for the Unionmelt department.

Personals

Arvid N. Anderson was graduated from the Colorado School of Mines in May, and is now employed by the Aluminum Co. of America as a junior metallurgist in the Cleveland sand foundry.

Owen M. Katz, who received a B.S. degree in metallurgical engineering from Carnegie Institute of Technology in June 1954, is now employed as a research metallurgist at the Hazelwood laboratory of the Jones & Laughlin Steel Corp.

Donald K. Fox has accepted a position with Westinghouse Electric Corp., and is a member of the student graduate training program in Wilkinsburg, Pa.

John P. Frank, since graduation from the University of Wisconsin, is employed in the metals research laboratories of Union Carbide and Carbon Corp. at Niagara Falls, N. Y.

Earl J. Bleakley, formerly assistant chief metallurgist for Jeffrey Mfg. Co., Columbus, Ohio, is now chief metallurgist for the Columbus Bolt & Forging Co.

Walter C. Kahn was recently elected vice-president in charge of engineering and industrial sales, Eastern Products Div. of the Oklahoma Steel Castings Co., Inc., Freeland, Pa. Mr. Kahn is also vice-president in charge of engineering for Bell Mfg. Corp. in the same city. Both companies are subsidiaries of American Steel and Pump Corp., New York City.

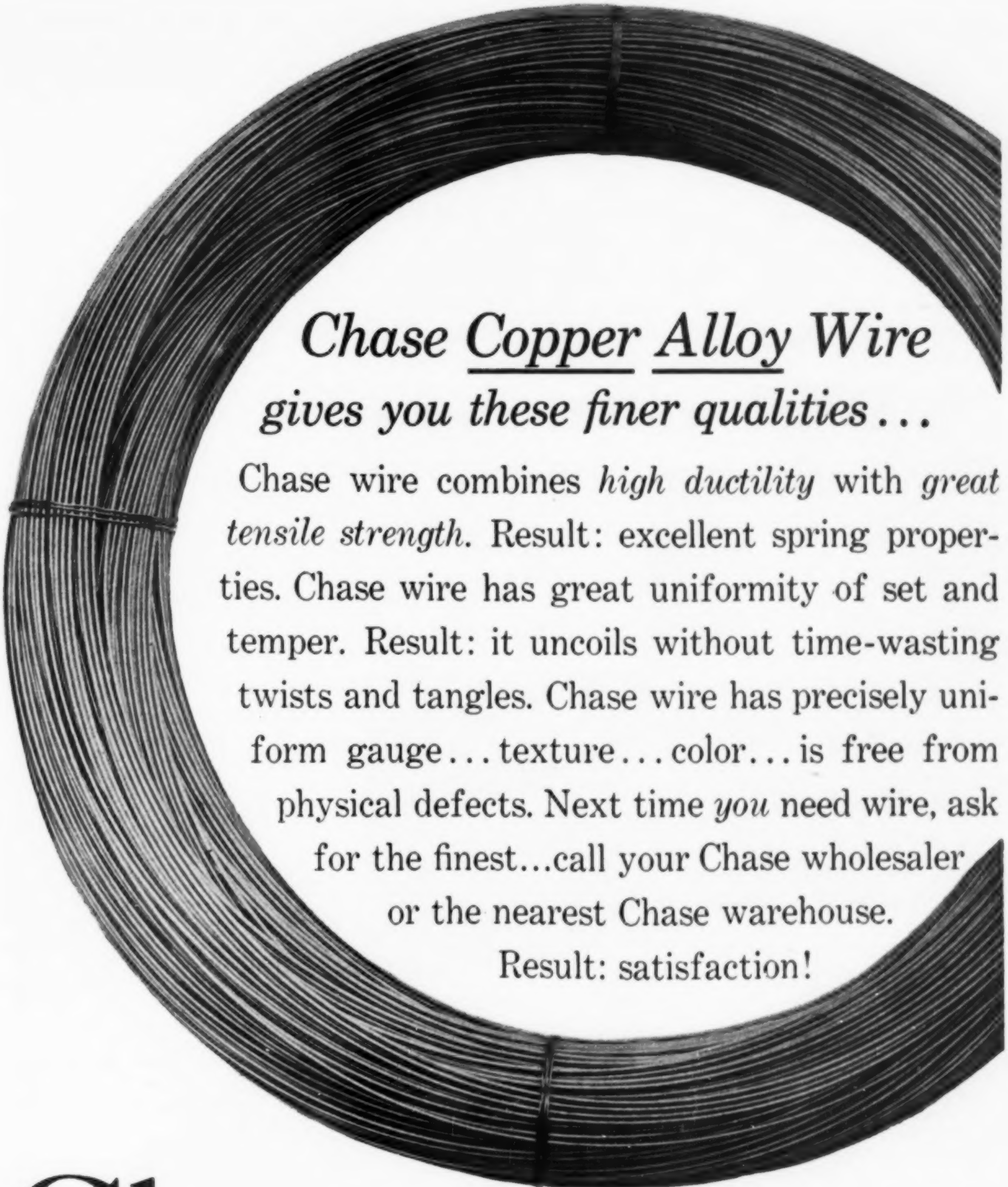
William B. Wallis, president of Pittsburgh Lectromelt Furnace Corp., has been given the University of Pennsylvania Distinguished Alumnus Award for 1954 in recognition of his outstanding work in developing and introducing the electric furnace for production of special alloy steel.

Edwin H. Engel has joined Follansbee Steel Corp., Follansbee, West Va., as chief of quality control. For the past five years Mr. Engel has been chief metallurgical engineer and assistant to the general superintendent of Compania de Acero del Pacifico, Huachipato, Chile.

Paul Gordon has been appointed as associate professor of metallurgical engineering at Illinois Institute of Technology, Chicago. A former research associate at M.I.T., Dr. Gordon was an assistant professor in metallurgical engineering at Illinois Tech before joining the faculty of the University of Chicago in 1951.

Norman B. Pilling, director of the Bayonne Research Laboratory of the International Nickel Co., Inc., has assumed new duties as assistant to the vice-president–manager of the development and research division in New York. **W. Andrew Wesley**, assistant director, succeeds Mr. Pilling as head of the laboratory with the title of manager. **John T. Eash**, metallurgical supervisor and head of the ferrous castings section of the laboratory, becomes assistant manager.

John W. Bolton has retired as chief metallurgist and research director of the Lunkenheimer Co., Cincinnati, Ohio, and **Marvin L. Steinbuch**, formerly assistant director of the metallurgical research and testing division, has been named as his successor.



Personals

Harold W. Miller, formerly assistant general superintendent for the Carpenter Steel Co., Reading Pa., has been advanced to chief plant engineer.

Alfred J. Brothers has been released from active duty with the Navy and has accepted a position as junior engineer with Consolidated Vultee Aircraft Corp. in San Diego, Calif.

Recent appointments to the staff of one of the Atomic Energy installations operated by Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp., include **John I. Federer** from University of Kentucky and **Carl F. Leitten, Jr.** from University of Notre Dame, as metallurgists; and **Robert E. Clausing** from University of Cincinnati, **Glenn E. Elder**, formerly with the University of Tennessee, and **Robert E. Waugh** from Cornell University, as metallurgical engineers.

Edwin C. Goetemann has been appointed district manager in the newly opened St. Louis offices of Universal-Cyclops Steel Corp.

Carl McLaughlin, formerly assistant to the executive vice-president of Tube Turns Div. of National Cylinder Gas Co., has been named executive vice-president of Tube Turns Plastics, Inc., a new company formed to manufacture industrial plastic pipe fittings and custom-molded products.

Latrobe Steel Co., Latrobe, Pa., has announced the appointment of **R. C. Kohl** as special sales representative in the Buffalo territory. **R. A. Gleason,** former sales representative, becomes district sales manager of the Buffalo office. **T. A. Curtis**, sales representative attached to the Newark, N.J., sales office, will move to Rochester, N.Y., to become a resident salesman there. **R. J. Tobey**, salesman for Missouri, will become a resident salesman at Fort Wayne, Ind.

Pfc. James F. Watson has been assigned as a metallurgist in the Shaped Charges Branch of the Ballistic Research Laboratory at Aberdeen Proving Ground.

The Carpenter Steel Co., Reading Pa., has appointed **O. T. Thompson** assistant branch manager of the Detroit territory, and **R. A. Kokat** assistant branch manager of the Philadelphia operations. Both men were previously sales engineers in their respective areas.

Joseph B. Clough has been promoted from director of sales to vice-president–sales, for National Tool Co., Cleveland.

Clayton D. Grover, formerly vice-president, has been elected president of Whitehead Metal Products Co., Inc.

Robert M. Baird, formerly with P. R. Mallory & Co., Inc., is attending Purdue University where he is a full-time graduate student in chemical and metallurgical engineering.

D. C. Bertossa, formerly research metallurgist with Wyman-Gordon Co., Worcester, Mass., has joined Chicago Bridge & Iron Co., Birmingham, Ala., as metallurgical engineer.

Personals

E. A. Lampman ⊕, for 12 years in charge of the Pittsburgh office of the Acheson Colloids Co., has been transferred to Rochester, N. Y., as territorial supervisor.

Robert R. Penman ⊕, formerly plant metallurgist for Macon Arms Inc., is now production metallurgist for Rem-Cru Titanium, Inc., Midland, Pa.

Bryan McPherson ⊕ has graduated from the University of Alabama, and has joined the melting department of Sivyer Steel Casting Co., Milwaukee, Wis., as an apprentice melter.

Eugene H. Kinelski ⊕ has joined the organization of Dwight-Lloyd, Inc., division of Sintering Machinery Corp., where he will be engaged in the research, development and sale of Dwight-Lloyd ore beneficiation plants and sintering and pyrolizing equipment in the metallurgical field.

W. H. Reas ⊕ is now in charge of chemical research with General Electric's Chemistry Unit, Engineering Department, at the Hanford atomic installation near Richland, Wash. Mr. Reas has been responsible for developmental plutonium recovery facilities at Hanford.

Chester A. Sellen ⊕, formerly chief metallurgist and assistant to the general manager, has been appointed assistant general manager and chief metallurgist for the Reliance Div. of Eaton Mfg. Co., Massillon, Ohio.

Walter L. Finlay ⊕, manager of research for Rem-Cru Titanium, Inc., has been named a vice-president of the company.

Harry J. Duffy ⊕, formerly plant superintendent, Trent Tube Co., has been appointed manager of sales in the Wisconsin, Minnesota, and Michigan territories.

George Perkins ⊕, general director of products and applications for Reynolds Metals Co., Louisville, Ky., has been appointed director of the Aluminum-Magnesium Div. of the Business and Defense Services Administration, U.S. Department of Commerce. He will serve the Government on loan from Reynolds and without compensation.

Personals

Major Joseph E. Black has recently been transferred to the Pentagon, Washington, D.C., assigned with the Research and Materials Div. of the Office of Chief of Ordnance, where he is working with the Deterioration Prevention Group.

Martin L. Potter is working in the Central Alloy District of Republic Steel Corp. in Massillon, Ohio, in the metallurgical laboratory as a stainless development metallurgist.

Dan White has left the National Advisory Committee for Aeronautics and is now offering a consulting service in Cleveland under the name of White-Simon, Scientists-Engineers. Mr. White's field is mechanical engineering, welding and fabricating, and Dr. Simon's is atomic physics. The firm will also have access to experts in various other fields as well.

Herbert C. Beik is now district manager of the Chicago Office, North American Mfg. Co.

Stanislaw T. Jazwinski, formerly chief research metallurgist, has been appointed director of research for Central Iron & Steel Co., Harrisburg, Pa., Phoenix Iron & Steel Co., Phoenixville, Pa., and Chester Blast Furnace, Inc., Chester, Pa., all subsidiaries of Barium Steel Corp.

Robert W. Bohn, B.S. in Metallurgical Engineering, Case Institute of Technology, June 1954, is employed at Sandusky Foundry & Machine Co., Sandusky, Ohio, as project engineer.

Roland J. Berkol recently joined the metallurgical staff of Rotary Electric Steel Co., Detroit, as stainless service metallurgist. Before coming to Rotary he spent 15 years at the Rustless Div., Armco Steel Corp., Baltimore, Md., and, more recently, four years with Atlas Steels Limited, Welland, Ont., Canada.

Jack A. May, a recent graduate of the University of Washington, is employed as a junior research engineer in the material and process division at North American Aviation, Inc., El Segundo, Calif.


A
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MURRAY-WAY
the automatic way
the economical way
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to POLISH ... BUFF ... GRIND ... FILTER
Whatever your job . . . whatever your problem . . . Murray-Way automatic equipment will do that job better and more economically.
These are just a few illustrations of Murray-Way's success in beating production cost with the finest automatic equipment available.
You can depend on Murray-Way engineering, Murray-Way experience, Murray-Way equipment to solve your production problems.
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G. Indexing Dial Table
H. Six Micro-Polish Units in Series
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MURRAY WAY CORPORATION
H

Personals

William J. Dell ●, formerly metallurgist for John Deere, Plant Works, Moline, Ill., is now the plant metallurgist for Arcade Malleable Iron Co., Worcester, Mass.

Barry Goldblatt ● has received the degree of B. S. in chemical engineering from Lehigh University and is working towards his M. S. in metallurgical engineering at the University of Pennsylvania under the Barium Steel Corp. fellowship.

Frederick Wellman ● has graduated from Grove City College and is now employed by the Bucyrus-Erie Co., Erie, Pa.

Wallace D. Edsall ● has graduated from University of Pittsburgh with a B.S. in Metallurgical Engineering and is now working at Allegheny Ludlum Steel Corp.'s forging and casting plant at Ferndale, Mich.

Vernon Verl Donaldson ●, formerly chemical engineer and metallurgist with U.S. Bureau of Mines at Albany, Ore., and Redding, Calif., is now with Westinghouse Electric Corp., materials manufacturing department, East Pittsburgh Works. His work involves the development of pilot manufacturing activities at the new Westinghouse plant under construction at Blairsville, Pa., and new project plans for other divisions of the company.

William T. Hunt ●, formerly chief metallurgist of the Chrysler Delaware Tank Plant, Newark, Del., has been appointed chief metallurgist of New Process Gear Corp., Syracuse, N. Y.

Fred R. Sullivan ● graduated from Drexel Institute of Technology and reported to Ashland Div., Armco Steel Corp. in June, where he is now employed as metallurgist on the newly installed Zincgrip line.

Joseph M. Fackelmann ●, on receipt of his B.S. in Metallurgical Engineering from Case Institute of Technology in June, accepted a position as metallurgical engineer with Battelle Memorial Institute.

Robert D. Lofgren, Jr. ● has accepted a position as president of United States Welding, Inc., Denver, Colo.

'54 Forecast: MORE ALUMINUM PRODUCTS THAN EVER BEFORE

Reynolds
ALUMINUM REPORTER

MODERN DESIGN HAS ALUMINUM IN MIND

★ ★ ★ Fifteenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

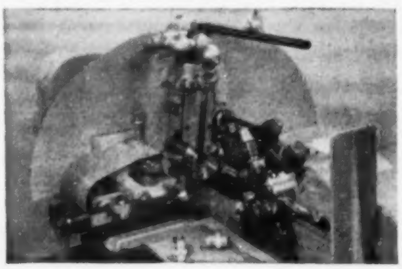
ALUMINUM DIE CASTINGS USED IN POWER MOWER

Reynolds Increased Wire, Rod and Bar Capacity Helps Meet Screw Machine Stock Demand

A new mill which has capacity to produce 36 million pounds of aluminum wire, rod and bar products annually has been completed at Sheffield, Alabama. This new mill, with 130,000 square feet of floor space, almost doubles Reynolds capacity for the production of these products—an important step toward keeping pace with many industry demands including the increased consumption of aluminum screw machine stock which has tripled in tonnage in the past six years. In this connection, it is interesting to note that there are 109,370 multi and single spindle screw machines in the country today.

Reynolds offers a complete line of aluminum screw machine alloys. They are excellent for screw machine work because, job for job, they machine at greater speeds and feeds—with standard tools, or with slight modifications for the higher speeds. You can increase production and cut material, handling and shipping costs with strong, lightweight aluminum that gives you three times the number of pieces per pound.

Rust-free aluminum often requires no finishing but, when needed, takes most of the regular metal finishes . . . also permits a wide choice of attractive anodized finishes in natural tones and sparkling colors.



For prompt delivery on aluminum screw machine stock plus design and fabrication engineering service, call the nearby Reynolds Office or Distributor listed under "Aluminum" in your classified telephone directory. They'll also show you how you can increase your sales and save your customers money if you submit alternate quotations based on aluminum when other materials are specified.

Send for 124-page handbook, "Machining Aluminum Alloys", and index of Reynolds Literature. Free when requested on business letterhead. Write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New RPM Lawn-Boy Uses Aluminum Die Castings for Light Weight, Strength, and Production Economies

The new Lawn-Boy Power Mower, made by the RPM Manufacturing Company of Lamar, Missouri, offers an outstanding example of how die cast aluminum parts benefit both manufacturer and consumer. Mower housing, incorporating a 45 cubic inch muffler, engine shroud and wheels are all die cast with Reynolds Aluminum. Die cast aluminum engine parts include starter pulley, flywheel, armature plate, crankcase, reed plate, carburetor, piston, connecting rod and sub base, all shown in the cutaway illustration.

RPM Lawn-Boy Power Mower

"Primarily, aluminum was chosen because it offers excellent durability with considerably less than half the weight of a comparable steel casting," says the RPM Company. "This 18" Lawn-Boy weighs only 37 lbs., but if the same mower were made of steel, it would weigh an estimated 93 lbs., 4 ozs.

"Also, aluminum transmits sound much less readily, thus producing a mower that absorbs rather than amplifies engine noise. From the production standpoint, aluminum is easily cast and lends itself well to difficult contours. It is less expensive both in design and production. It has what production men call 'machineability'. Because of its natural attractiveness and weather resistance, many aluminum parts need not be painted."

Remember—for die castings or any other aluminum parts, the assistance of Reynolds engineering and styling service is available without obligation to help manufacturers make full use of aluminum's many advantages. Consult Reynolds Specialists on your next design or redesign project. Call the Reynolds Office or your nearby Reynolds Distributor listed under "Aluminum" in your classified telephone directory. Or write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New Interlocking Ingot Introduced by Reynolds

This unique ingot design—another Reynolds Aluminum first—is more easily palletized, makes stronger bundles that arrive intact and are safer, easier to handle. Bundles can be double or triple stacked to provide shipping and storage economies. In addition, the greater surface area gives quicker melt down. A smoother top surface eliminates chances of trapped moisture and dirt.

For more complete information call the Reynolds Office or Pig and Ingot Distributor listed under "Aluminum" in your classified telephone directory or write direct.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

Aluminum Foil Protects Mainsprings of Watches

Aluminum foil, popular in homes as a protective wrapping material, is finding increasing application in industry. A new use is reported by Hamilton Watch Company, Lancaster, Pennsylvania, who wraps trays of its Dynavar mainsprings in foil before heat-treating.

The Reynolds Wrap is used as a precautionary measure to keep the springs clean until placed in a vacuum furnace, and to protect the springs' bright finish from possible oil or vacuum leaks which might cause discoloration during the four hours they are heat-treated in the furnace.

The watch firm also uses the foil to protect its dies, tool steel parts, and machined components during tempering. Wrapping the parts in Reynolds Wrap before tempering at temperatures below the melting point of the wrap prevents atmospheric discoloration and contamination of the parts. This retains the bright finish of the heat-treated parts and eliminates a cleaning operation which might otherwise be necessary.

For more information on aluminum foil as a protective industrial packaging material, write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Reynolds *Do-It-Yourself* Aluminum Used in Plant Maintenance Projects

Reynolds *Do-It-Yourself* Aluminum, a special type of aluminum alloy primarily for home maintenance and improvement projects, is also being used in plant maintenance work.

Reynolds *Do-It-Yourself* Aluminum can be worked without special tools. You can saw it, plane it, joint it, shape it and drill it with standard woodworking hand or power tools.

Reynolds *Do-It-Yourself* Aluminum also has the rustproof qualities, permanence and attractiveness of regular aluminum.

Reynolds *Do-It-Yourself* Aluminum is available in tubing, rods, bars, angles, plain, embossed and perforated sheets, screws and other fasteners.

Chances are, this amazing new material can be put to work in countless maintenance and improvement projects around your plant. For a complete package assortment of Reynolds *Do-It-Yourself* Aluminum, see your hardware supply house. Individual items are available at hardware and building supply dealers. For full details write Reynolds Metals Company, 2576 So. Third Street, Louisville 1, Kentucky.

Press Parts From Reynolds Aluminum Fabricating Service Help Give You the Most From Your Designs

Appliance, automotive, houseware and many other manufacturers in widely diversified industries are relying on Reynolds Aluminum Fabricating Service for the production of aluminum parts ranging from a small aluminum tumbler to a one-piece 12′ by 4′ 8″ aluminum boat hull.

Reynolds A54S Alloy Benefits Tank Industry

An aluminum-magnesium alloy of particular interest to the tank industry is now available from Reynolds Metals Company. This alloy, A54S, is available as sheet and plate in the annealed and intermediate (work hardened) tempers. It has properties between 52S and 56S with mechanical properties somewhat higher than those of 52S and in some tempers comparable to those of 61S-T6.

The excellent corrosion resistance, weldability and strength of A54S make it ideal for tank construction of all types, especially those required to hold pressure. It has been found that the high strength of welded A54S makes possible the use of lighter gauges in the manufacture of pressure vessels, thus reducing material costs. Several tank manufacturers have indicated that material cost reductions effected by going to A54S are in the neighborhood of 20%.

Ammonium nitrate fertilizer tanks, trucks, trailers, tank trailers, ships and other welded assemblies are a few of the places where the A54S alloy offers definite advantages.

For full details call the Reynolds Office or Distributor listed under "Aluminum" in your classified telephone directory. For your free copy of the 130 page handbook, "Aluminum Structural Design," and a complete index of other literature, write on business letterhead. Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

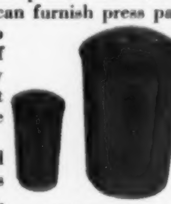
Aluminum Advantages Aid Pulp and Paper Industry

An increasing interest in the use of aluminum in the pulp and paper industry is being shown by mill operators and management because of aluminum's light weight, resistance to corrosive fumes and low maintenance costs.

Aluminum and its alloys are being used in the plants for ventilating ducts, screen covers, walkways, railings, ladders, bus bars, suction boxes, conduit and pipe lines for nitric acid and distilled water. In the woods and logging divisions, aluminum logging chutes and flumes are being used successfully.

There are serious corrosion problems in this industry, not only with the equipment used for the chemical production of pulp but with the metals used in the plant structure. While such members are not in actual contact with the processing liquors they are subjected to the action of chemical fumes, dusts, dirt and moisture. Chemical dusts and dirt deposited on a metal may stimulate corrosive attack because they can retain moisture and some may even become liquid by absorbing moisture from the air. Aluminum's resistance to these contaminants is well known.

In two plants alone, Reynolds offers 128 presses including mechanical presses from 2 to 1700 tons and hydraulic presses from 300 to 5000 tons. Reynolds can furnish press parts from simple blanks to deep drawn parts of large area; from very thin to the thickest aluminum that can be drawn.

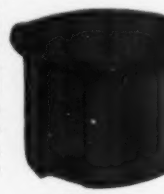


Aluminum Pitcher and Tumbler

If your designs call for aluminum parts that require blanking, punching, drawing, forming, stamping, piercing, or other press operations, Reynolds Aluminum Fabricating Service can produce these parts to your specifications.

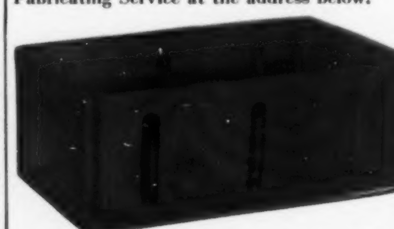
Aluminum Truck Wheel

The great variety of Reynolds specialized equipment permits you to obtain the economy of the machines best suited to your purpose without making the tremendous capital investment in equipment and added plant capacity which would otherwise be required. Reynolds quality control from mine to finished product and Reynolds experienced design and engineering service go hand in hand with these facilities to assure you the most from your designs.



Aluminum Deep Well Cooker

For full details call your nearby Reynolds Office or write to Reynolds Aluminum Fabricating Service at the address below.



Aluminum Medical Chest

A free 24 page "Catalog of Facilities" is available by writing Reynolds Aluminum Fabricating Service, 2065 South Ninth Street, Louisville 1, Kentucky. Other catalogs covering Appliance Parts and Roll Formed Shapes are also free on request.

Digests of ASM Convention Papers

Phase Relationships in the Al-V Alloy System*

THIS STUDY represents an investigation of the aluminum-vanadium system covering the entire composition range. It was shown that the solid solubility limit of vanadium in aluminum is 0.37% vanadium at 660° C. (1220° F.) and lower temperatures. Four intermediate peritectic phases have been identified from microstructures and X-ray data. These phases are: α aluminum-vanadium, identified as $Al_{11}V$ (14.6% V), which exists at about 14% vanadium and undergoes peritectic transformation at 685° C. (1265° F.); β aluminum-vanadium, identified as Al_6V (23.9% V), which exists at about 24% V and undergoes peritectic reaction at 735° C. (1355° F.); γ aluminum-vanadium, previously established as Al_3V (38.6% V), which undergoes peritectic transformation at 1360° C. (2480° F.); and the fourth, δ aluminum-vanadium, identified as Al_8V_5 (54.2% V), which occurs at approximately 56% V and undergoes peritectic transformation at 1670° C. (3038° F.). The vanadium-rich section of the diagram is represented as a region of extensive solid solution of aluminum in vanadium extending to 70% V.

In discussing their results, the authors state that the phase relationships near pure aluminum at its melting point may not be properly represented in the diagram. The heating and cooling curves for the 5 and 10% vanadium alloys had distinct breaks at 1220° F., and the method of analysis was not sufficiently accurate to determine whether the transformation was eutectic or peritectic in nature.

The location of the solvus for the vanadium region of the diagram was determined by X-ray diffraction studies of six alloy compositions in the solid solution region for the relationship between the lattice constant of vanadium and atomic percentage of aluminum in solution. Single crystals of some of the phases, derived from slowly cooled castings, enabled very accurate X-ray analytical work.

There appears to be a slight tendency for a maximum in the solidus at 98 to 99% vanadium. This discrepancy, however, may result from impurity effects or scatter due to inaccuracies in the measurements.

Alloys were prepared from massive aluminum having a reported purity of 99.9% and vanadium prepared in the authors' laboratory by the reduction of vanadium pentoxide with calcium. All alloys were prepared by arc melting 10-g. samples of the vanadium and aluminum several times and inverting the ingots between melts. In the range 0 to 30% vanadium, where alloy segregation was usually more pronounced, the alloy ingots were cold pressed, sectioned into small pieces and given another series of arc meltings. Some aluminum usually volatilized during the preparation of the vanadium-rich alloys (to the extent of 1 to 2%). A peculiar phenomenon occurred in the range of 40 to 60% vanadium which prevented accurate determination of the nominal composition of the alloy – during cooling after solidification, these alloys would shatter and sometimes explode with considerable violence.

A homogenizing vacuum heat treatment was given most of the samples after cold working. Quenching experiments were carried out by annealing the alloy specimens, admitting helium into the system at temperature and quenching in water.

The phase diagram was constructed on the basis of microscopic, X-ray, and thermal data. Examination of the samples under polarized light proved useful in differentiating phases since two of the four intermediate phases were anisotropic. Phase identification was carried out using X-ray diffraction data derived from Debye-Sherrer patterns.

Because of the reactivity of the alloys, thermal data were obtained from samples treated under vacuum or inert atmosphere. Solidus points above this temperature were determined with an optical pyrometer on samples heated by either induction or internal resistance.

R. L. FOLKMAN

*Digest of "The Aluminum-Vanadium Alloy System", by O. N. Carlson, D. J. Kenney and H. A. Wilhelm, ASM 1954 Preprint 1.

Effect of Carbon and Nitrogen on Martensite Hardness*

THE MAXIMUM attainable hardness of low-carbon high-alloy steels, such as the martensitic stainless types, is commonly observed to be somewhat greater than would be predicted from the Burns, Moore, and Archer relationship between carbon content and martensite hardness. The work described in this paper was carried out to evaluate the relative importance of several possible explanations for this discrepancy.

Two factors were found to be responsible. First, higher hardnesses can be obtained in steels with less than 0.10% carbon and 0.01% nitrogen than the Burns, Moore, and Archer relationship would indicate. Second, the attainable hardness is shown to be a function of nitrogen as well as of carbon content. There is no evidence that chromium, although varied from 0.5 to 15.5%, has any effect on the attainable hardness of these low-carbon chromium steels. Similarly, there is no correlation of hardness with any of the other alloying elements.

Data were obtained on 54 experimental steels with 0.035 to 0.16%

*Digest of "Effect of Carbon and Nitrogen on the Attainable Hardness of Martensitic Steels", by A. E. Nehrenberg, P. Payson and P. Lillys, ASM 1954 Preprint 16.

Martensite Hardness . . .

carbon and 0.5 to 15.5% chromium. In the lower chromium steels, additions of up to 6% nickel and 3% manganese were made. Nitrogen was varied from 0.03 to 0.30% in the 12 to 15% chromium steels. All heats were induction melted, cast into 15-lb. ingots and forged to ⅝-in. square bars. Test specimens ¼ in. thick were cut from each bar after a subcritical anneal, austenitized at 1800, 1900, and 2000° F., water quenched and immediately refrigerated at −320° F. to minimize retained austenite. Hardness data were obtained on those specimens which were fully martensitic and free from residual carbides.

Conventional statistical procedures were employed to analyze the data. For these low-carbon steels, the relationship between carbon or nitrogen and attainable hardness is approximately linear on log-log coordinates, suggesting an empirical equation of the form:

$$\log(\text{Rockwell-C hardness}) = a + b\log(\%\ \text{carbon}) + c\log(\%\ \text{nitrogen})$$

Solution of this equation provided reliable hardness estimates for the low-carbon steels, but gave low estimates for the higher carbon contents, such as those which comprise the bulk of the data reported by Burns, Moore, and Archer.

To provide a relationship having validity over a wider range of carbon content, a new regression equation was developed, incorporating the Burns, Moore, and Archer data, which yielded the following empirical relationship:

$$\log(\text{Rockwell-C hardness}) = 2.182 + 0.469\log(\%\ \text{carbon}) + 0.108(\log\ \%\ \text{carbon})^2 + 0.164\log(\%\ \text{nitrogen}) + 0.025(\log\ \%\ \text{nitrogen})^2$$

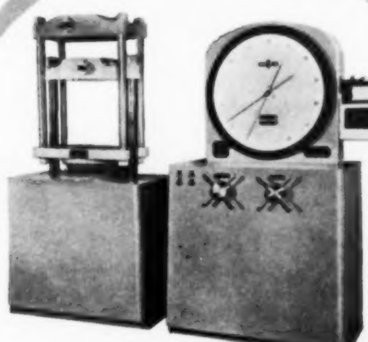
Attainable hardnesses computed from this equation are in good agreement with observed values.

The standard error of each of the four regression coefficients is shown, as well as the coefficient of multiple determination for the whole regression equation. After further allowance for chance variation, it is concluded that the regression equation accounts for at least 96% of the total variability in log (Rockwell-C hardness).

The data were further analyzed statistically to determine if any of the unexplained variance in log (Rockwell-C hardness) was attributable to variations in alloy content. No correlation was found with chromium content or with any of the other alloying elements.

The results are in disagreement with the work of Bain which showed that the maximum hardness of 0.02% carbon, iron-chromium alloys increased with increasing chromium. The authors suggest that it is possible that the effect observed might be attributable to nitrogen (not reported) which tends to increase with increasing chromium, rather than to actual chromium variation.

Graphs are presented delineating the relationships between carbon and nitrogen and attainable hardness. The effect of nitrogen is not as great as that of carbon, but it is pronounced. At 0.10% carbon, for example, an increase in nitrogen from 0.01 to 0.5% increases the attainable hardness from Rockwell C-39 to 44.5.   C. R. Wilks



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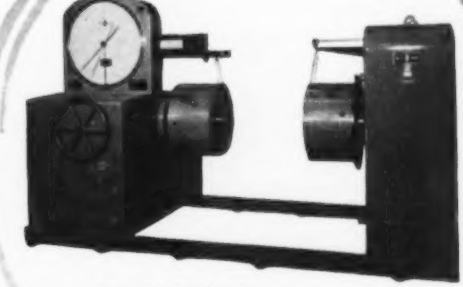

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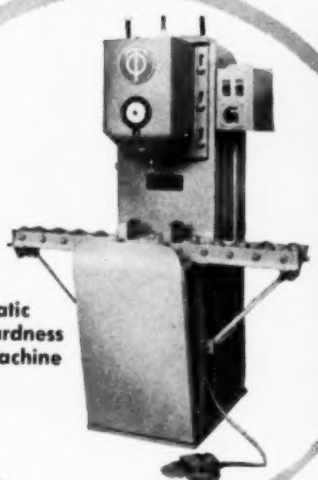

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Texture of Warm Rolled Steel*

WHEN low-carbon steel is rolled at ordinary temperatures, the conventional cold rolled texture is developed for which the preferred orientation is described as (001) [110] (face of the elementary cube in the rolling plane and the diagonal of the cube face in the rolling direction). A recent investigation has revealed that when the rolling temperature exceeds 500° F., the resulting texture is of the type (110) [001] (diagonal plane of the cube in the rolling plane and the cube edge in the rolling direction). In the present work the influence of mill variables such as speed of rolling, the amount of reduction per pass and the use of forced cooling were explored. Such variables may well account for rolling temperatures in excess of 500° F. although the processing is still in the "cold" rolling range (below 1300° F.).

Samples of strip prepared by three conditions of rolling were studied. The first, which was designated the "cold rolled" sample, was rolled on a cold mill that had been idle overnight. Thirteen passes and a speed of 220 ft. per min. were used to reduce the strip. The average surface temperature of the sample was in the range 100 to 135° F. The second sample, designated "normal rolled" was prepared after the mill had been in operation for sufficient time to warm up and the strip speed was increased to 1000 ft. per min. The number of passes to achieve the same 75.9% reduction was reduced to nine while the surface temperature was in the range of 185 to 230° F. The "warm rolled" sample was prepared after the mill had become quite hot and a speed of 1300 ft. per min. was used to reduce the sample 75.9% in six passes. Although the surface temperature after each five passes was between 220 and 335° F., it was as high as 620° F. after the last pass. Textures on the surface of the samples, on a plane one quarter of the distance through the thickness, and on the central plane half-way through the thickness were identified. An X-ray diffraction method that employed surface reflection and film recording was used.

The (110) [001] texture is primarily a surface effect on the "warm rolled" specimens, for this type was present on the unetched surface of only the "warm rolled" sample; on the plane one-quarter way through the thickness this texture was mixed with the conventional, while at the center of the "warm rolled" sample the conventional (001) [110] cold rolled texture occurred. The latter was present at all three levels through the "normal rolled" and "cold rolled" samples but sharper at the center of the thickness.

In addition the textures at the three locations of the "cold rolled" sample were sharper than those at the corresponding locations in the other two samples.

A. H. GEISLER

*Digest of "The Zonal Rolling Texture of Low Carbon Steel Cold Rolled at Various Temperatures", by C. Nussbaum and William Brenner, Jr., ⓐ 1954 Preprint 12.

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Magnetic Detector for Transformation Determinations*

SINCE the procedure for developing isothermal and continuous cooling diagrams is extremely time-consuming, an apparatus was designed to utilize the magnetic changes accompanying the transformations in steel so as to simplify such studies. This magnetic detector uses the principle that an e.m.f. is induced in the secondary winding when the core of a transformer is magnetized. The specimen of steel, on which measurements are to be made, forms the core of this transformer. When the specimen becomes ferromagnetic, an alternating current is produced in the secondary winding. The secondary output is connected to a copper oxide rectifier and the direct-current output from the rectifier is fed to two variable resistors connected in series. The desired potential for the recording potentiometer is obtained by adjusting these variable resistors. An auxiliary circuit is required to compensate for the slight coupling effect in the detector circuit when no specimen is in the transformer. The specimen consists of a solid bar ¾ in. diameter by 3 in. long. Midway along the length of the specimen, a chromel-alumel thermocouple is welded to the outer surface which is connected to a high-speed temperature-recording potentiometer.

The specimen is placed in a tube furnace for heating. A dried nitrogen atmosphere is used to prevent decarburization and scaling during the austenitizing heat treatment. After austenitizing, the specimen is quickly placed in the magnetic pick-up coil, the temperature and magnetic recorder drives are started simultaneously, and the pick-up coil with sample is submerged in the quenching medium contained in a glass receptacle to minimize any outside effects on the pick-up coil.

In most instances the magnetic method gave a slightly higher M_s value than either the metallographic or calculated methods. The magnetic method is sensitive to inhomogeneities in the steel, and a slight amount of banding or carbon segregation produces a higher M_s temperature by the magnetic method.

An attempt was made to relate the percentage of martensite with permeability. Although a relationship probably exists, it could not be definitely established.

The continuous cooling curve for S.A.E. 4340 steel derived by the magnetic method agreed satisfactorily, in the austenite-to-bainite region, with the curve calculated by Grange and Kiefer, but differed significantly in the location of the austenite-to-ferrite transformation region. The M_s temperature derived from the continuous cooling tests was also higher than that of the calculated curve. No similarity was noted between the calculated curve for S.A.E. 4363 steel and that derived by the magnetic method. The discrepancies observed indicate that more work of this type remains to be accomplished. W. O. BINDER

*Digest of "A Method for Determining the Continuous Cooling Transformations in Steel", by R. D. Chapman and W. E. Jominy, 1954 Preprint 33.

Deformation in Magnesium*

As a possible means of explaining the observed physical properties of metals on a fundamental basis, concerted efforts have been made in recent years in studies of deformation in metal single crystals. Only a few have made such studies on polycrystalline aggregates. This paper reports the initial results of such a study, in which the deformation mechanisms in magnesium have been observed at ambient temperature. Magnesium was chosen for study because of the limited number of deformation mechanisms which are known to have been observed previously in monocrystal specimens.

The fact that polycrystalline magnesium undergoes plastic deformation requires five independent mechanisms, since a general deformation involves six strain components. Basal slip can account for two of the five mechanisms; the remaining three remain to be determined, twinning being excluded because of the nearly theoretical axial ratio for close packing being maintained.

High-purity extruded magnesium rods, machined into tensile specimens, were annealed 6 hr. in SO_2 at 600° C. (1110° F.) and electropolished. Average grain diameter was 0.05 in. Certain specimens were lightly scribed to produce 0.0200-in. square grids, while others were used as prepared. Orientations of 39 different grains in one sample were followed during deformation. Texture studies prior to deformation indicated a preferred orientation of basal plane parallel to extrusion axis, equal scattering in all directions being observed for $[11\bar{2}0]$ slip directions.

Slip bands in each grain were parallel, and all were in agreement with the (0001) $[11\bar{2}0]$ mechanism. No evidence of pyramidal slip was observed, nor was there any indication that duplex slip occurred. Data showed that favorably oriented grains began to slip at lower tensile stresses than less favorably oriented neighbors. On the other hand, resolved shear stresses at which slip initiated showed considerable scatter from grain to grain, in a completely random fashion.

Some twinning was observed during specimen loading, and additional twinning during unloading. Mechanical twinning occurred on $(10\bar{1}2)$ planes only, in the $[10\bar{1}1]$ directions. Twins grew in a uniform manner, bilaterally if unrestrained, unilaterally if constrained. It was possible to detwin by stress reversal. As many as five pyramidal planes were observed to twin in a single crystal.

It has been suggested that bending must exist in order to produce twinning, since some distortion of the crystal must inevitably accompany this action. In addition to simple shear, secondary adjustments at right angles to the twinning direction are necessary, and could be achieved by pre-bending on a $(11\bar{2}0)$ plane. Termination of twins

(Continued on p. 170)

*Digest of "Deformation Mechanisms in Polycrystalline Aggregates of Magnesium", by F. E. Hauser, C. D. Starr, L. S. Tietz and J. E. Dorn, ⊕ 1954 Preprint 8.

Deformation . . .

at traces of $(11\bar{2}0)$ planes substantiates this hypothesis. The test specimens failed to reveal such bending.

Twinning results in a decided bending of the basal plane, this phenomenon being termed an accommodation plane. This study showed that these low-angle boundaries moved in conjunction with twin growth, extending with the twin and increasing in angular tilt. Evidence is thus obtained which indicates a mobile low-angle twin boundary under stress at room temperature.

Occasional low-angle boundaries were observed to originate in the interior of a grain and traverse from one grain to another with no apparent discontinuity at the grain boundary. Movements appeared to be linear in relation to applied stress, and those oriented near 45° to the tensile stress seemed to be most mobile.

Extensive evidence of grain boundary shearing was observed at strains as low as 0.16%. Both negative and positive shear was found. In those areas where shearing occurred at grain boundaries, fracture also occurred, and the basal planes of the grains were unfavorably oriented for slip. While the strain contribution from grain boundary shearing is small, its effect on subsequent deformation is quite great.

Cracks, originating at grain boundaries, were observed to grow interiorly, with parallel cracks forming in the same grain. Secondary sets of cracks were also observed, substantially normal to the maximum stress. Adjacent grains also cracked, in spite of their orientations being favorable for slip planes. The orientation of these cracks is thought to be $(10\bar{1}1)$.

Low-angle boundaries were evident at the crack tips, and always on the depressed side of the crack. The geometric relationships associated with cracks are therefore not unlike those relationships observed with slip planes.

Final rupture occurred by intergranular fracture of grains whose boundaries were approximately 45° to the stress direction, yielding a "saw-tooth" rupture that was normal to the stress direction.

J. L. Wyatt

Dependence of Microstructure on Hardenability*

When the hardenability of steels is determined with the end-quench test, such hardenability specimens contain structures which are the result of cooling conditions that vary from the drastic water quench to an air cool. These structures are martensite, pro-eutectoid ferrite (or carbide), upper bainite, lower bainite, pearlite, and a constituent associated with martensite that cannot be classified by optical microscopy.

The occurrence of certain structures resulting from heat treatment of steels can be predicted from isothermal or cooling transformation diagrams. Since transformation products are a result of an austenite change, it should be possible to predict their nature from some time-temperature relationship. Thus the purpose of this investigation was two-fold: to identify and to predict the nature of transformation products associated with martensite in incompletely hardened steels.

Six common hypo-eutectoid steels of about 0.40% carbon were chosen for this investigation: S.A.E. 1040, 1340, 4040, 4340, 5140, and 8640. The first three are shallow hardening, while the last three are relatively deep hardening steels. Data were obtained on standard end-quench hardenability bars machined from cold rolled rods of each steel, previously normalized for 4 hr. at 1650° F. The percentage of martensite was determined microscopically at 500 diameters on polished and etched surfaces. Cooling rates at 1300° F. for each 90%, 70% and 50% martensitic area were determined from the hardenability data and cooling curves, whereas the cooling transformation diagrams for each steel were plotted using the methods of Grange and Kiefer.

The Ms temperatures for the steels were calculated from the data published by the Republic Steel Corp., after the method of Grange and Stewart. The nature of transforma-

*Digest of "An Electron Metallographic Study of the Dependence of Microstructure on Hardenability", by S. T. Ross, R. T. Sernka and W. E. Jominy, 1954 Preprint 13.

Hardenability . . .

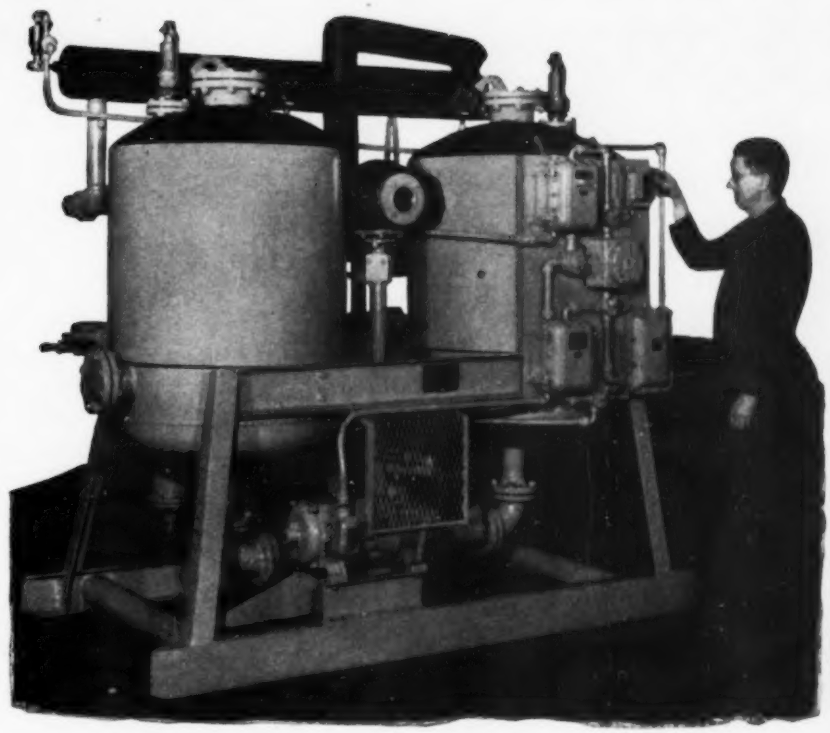
tion products was then predicted from consideration of the mode of intersection of the cooling curve with the diagrams.

Electron micrographs were taken at 4000 diameters and then enlarged to 15,000 diameters in such a manner that they represented the nature of the transformation products, and not necessarily their relative amounts at a given position. It was found that transformation products in the shallow hardening steels were predominantly pearlitic, although areas of carbide-free ferrite and upper bainite were found to coexist with pearlite and martensite. The deeper hardening steels contained upper and lower bainite and carbide-free ferrite as transformation products. The occurrence of pro-eutectoid ferrite in martensite of S.A.E. 4340 steel was observed but not predicted from consideration of the cooling transformation diagram. However, carbide-free ferrite was found in transformation products of the 4340 steel to the same relative extent as in the 5140 and 8640 steels. The martensite matrices appeared roughened and to have a subgrain structure. No lower bainite was found in the martensite of the shallow hardening steels, nor was any pearlite found in the martensite of the deeper hardening steels. From these studies it was concluded that the extent of the pro-eutectoid ferrite area of the cooling transformation diagram for 4340 is questionable on the basis of magnetic and electron microscopic evidence. Isothermal data on other steels also may require reinvestigation by these methods.

It is evident that the transformation products that could not be resolved with the light microscope are finely divided products of austenite decomposition; that is, ferrite, pearlite, upper and lower bainite. The martensite subgrain structure will require further investigation.

Consideration of the electron micrographs corroborates the concept that pearlite and upper and lower bainite are carbide-ferrite agglomerates differing only in the mode of their carbide precipitation. The amount of pro-eutectoid constituent may vary with the carbon content, but the arrangement of car-

(Continued on p. 176)



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bides within any given type of ferrite-carbide agglomerate in martensite is the same.

It should be emphasized that the three reactions: austenite to pearlite, austenite to upper bainite, and austenite to lower bainite, are similar in that all may be written as austenite to ferrite plus carbide. The electron micrographs show that the differences among ferrite-carbide agglomerates lie in the mode of carbide precipitation in ferrite. Therefore, it may be summarized that alloy content will not influence the configuration of ferrite and carbide in each decomposition product, but it will be a factor in determining which decomposition products will be present in the martensite of an incompletely hardened steel.

W. W. Austin

A Method for Calculating Hardenability*

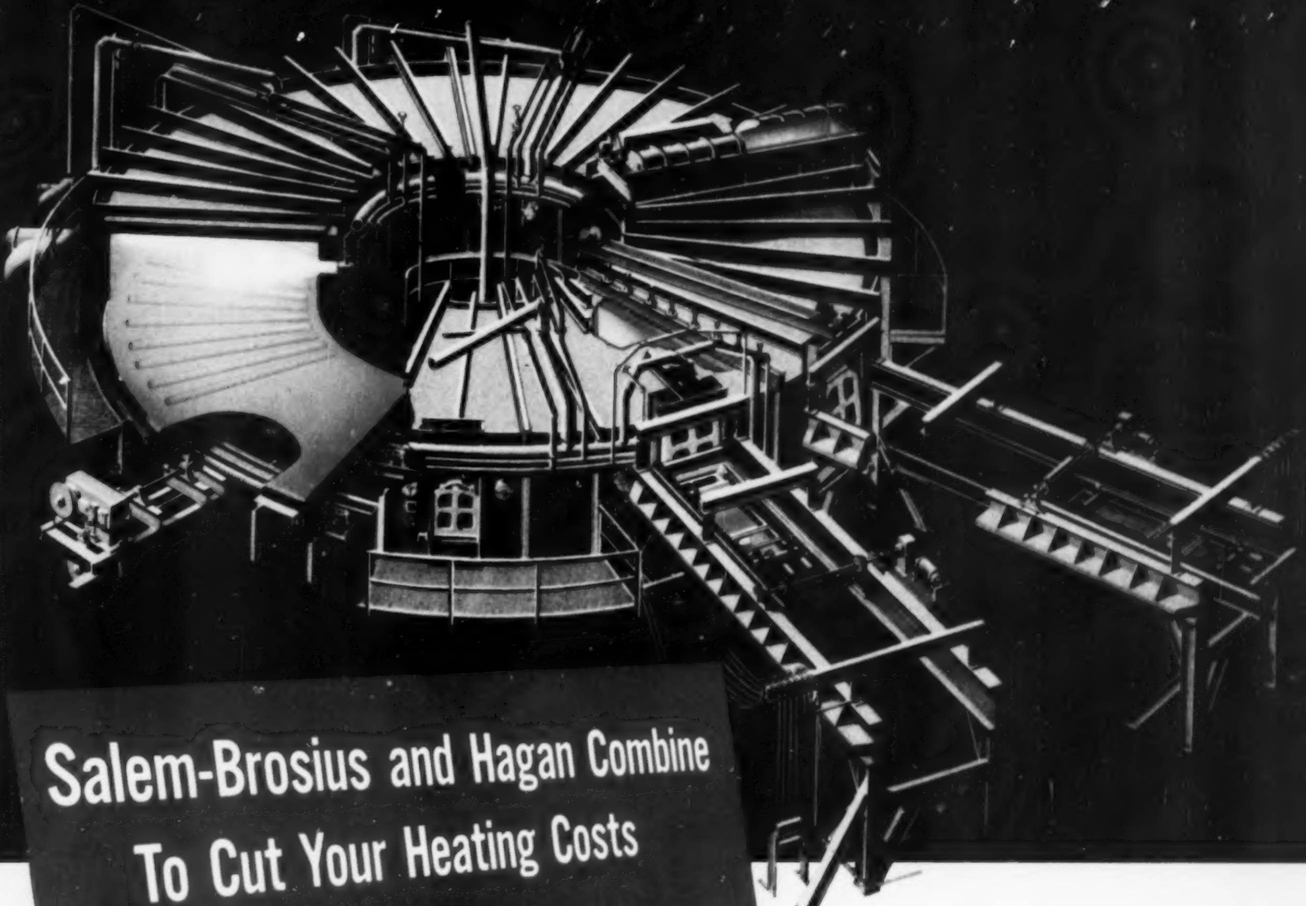
The effects of individual alloying elements on the hardenability of 1% carbon steels were determined from data collected over many years at Timken Roller Bearing Co. Hardenability tests were made after holding at commercial hardening temperatures of 1475, 1525 and 1575° F. for 35 to 40 min. The standard A.S.T.M. end-quench procedure was used throughout except for the final austenitizing in a neutral salt bath. The distance to Rockwell C-60 was used as the hardenability criterion and the D_I values were obtained from the Jominy distances by using the accepted conversion curve.

The carbon multiplying factors were derived from previously published data. Fracture grain sizes were obtained by comparing the fractures of thin slices cut from the quenched end of the Jominy bars with Shepherd standards.

The average of seven heats of representative 1% carbon toolsteel having an initial normalized struc-

(Continued on p. 178)

*Digest of "Calculation of Hardenability in High-Carbon Alloy Steels", by C. F. Jatczak and R. W. Devine, Jr., 1954 preprint 14.



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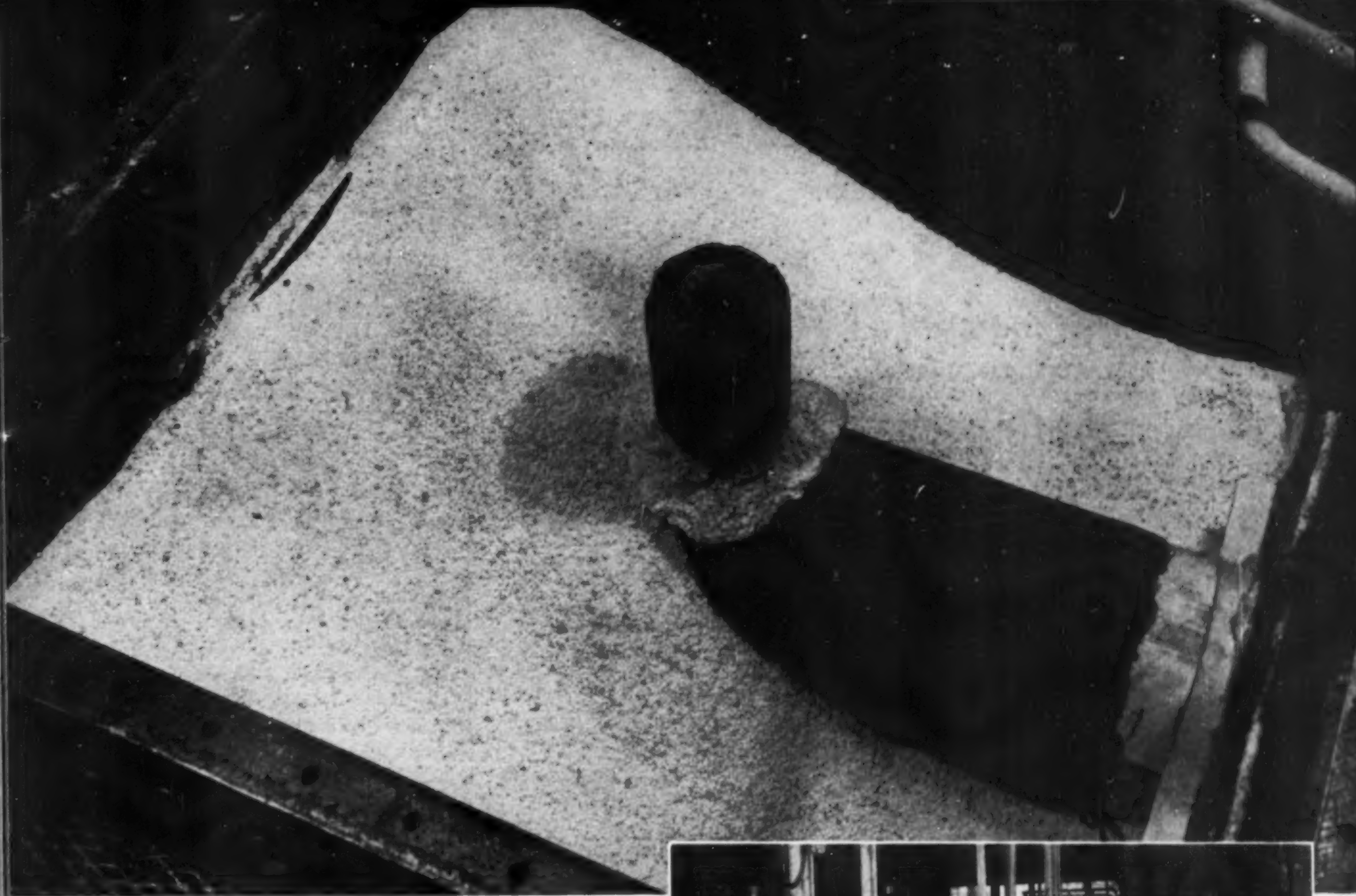
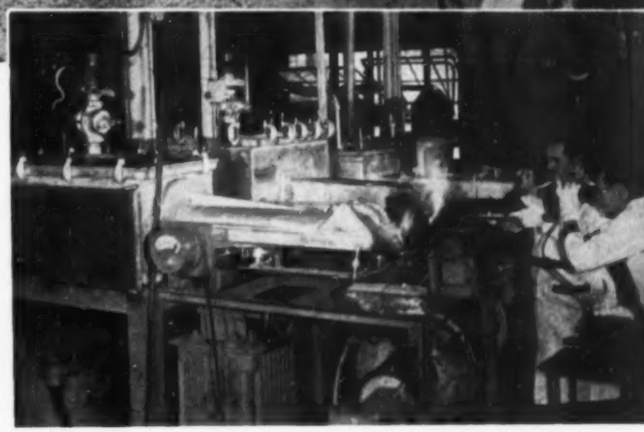
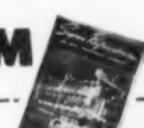






ture was used as the hardenability basis. The D_I values were corrected to 0.25% each of manganese, silicon, chromium and nickel, and 0% molybdenum. A series of steels alloyed with a single element provided the first approximation of the effects of each of these elements on hardenability. The measured D_I values were plotted against the element content and quenching temperature for each series. The curves were extrapolated to a 0.25% element content (0% Mo). These curves were used to adjust the D_I values for all single alloy steels whose residual elements did not fall on the base composition. The multiplying factor for each element was derived from the quotient of the adjusted D_I and the base D_I values.

The expected effect of quenching temperature on the multiplying factor for all carbide formers was observed. The nickel factors were independent of quenching temperature and silicon was assumed to behave similarly.

When these results were used to compute the hardenability of a number of chromium-nickel-molybdenum steels (whose hardenability data were available), the agreement rarely exceeded ±10% if the nickel was not higher than 1.0%. At the higher nickel contents an interdependence of the effects of manganese and nickel was noted. This difficulty was overcome by computing combined nickel-manganese multiplying factors. While molybdenum contributed to the hardenability in the high-nickel multi-alloy steels, it appeared independent of the other alloying elements. The chromium and silicon multiplying factors were unchanged in these steels.

The multiplying factor could not be used on the steels end-quenched from the spheroidized annealed prior structure. The limited data indicated a complex interrelationship between the alloying elements.

Use was made of a simple correlation between the D_I from the normalized prior structure and the corresponding value from the spheroidized anneal on all steels having both values. This simple relationship allows the calculation of the hardenability for annealed prior structures within ±15%. J. E. STUKEL

A Method for Predicting Hardenability*

THIS STUDY represents an investigation of five heats of relatively shallow hardening toolsteel. The purpose of the study was to introduce a series of curves for predicting hardness penetration in rounds of relatively shallow hardening carbon steel in terms of a fundamental parameter. The parameter chosen is the rate in degrees Fahrenheit per second at 1300° F. (705° C.) with which the steel must be cooled to attain the critical hardness which is associated with the 50% martensite, 50% pearlite structure. The critical hardness is Rockwell C-55 for the hypereutectoid steels investigated. In utilizing the curves, it is only necessary to quench a cylinder of the steel in question from 1450° F. (790° C.) into a well-agitated 10% brine solution at room temperature ($H = 4.00^{-in.}$) and then ascertain the critical cooling velocity or the depth of hardness penetration.

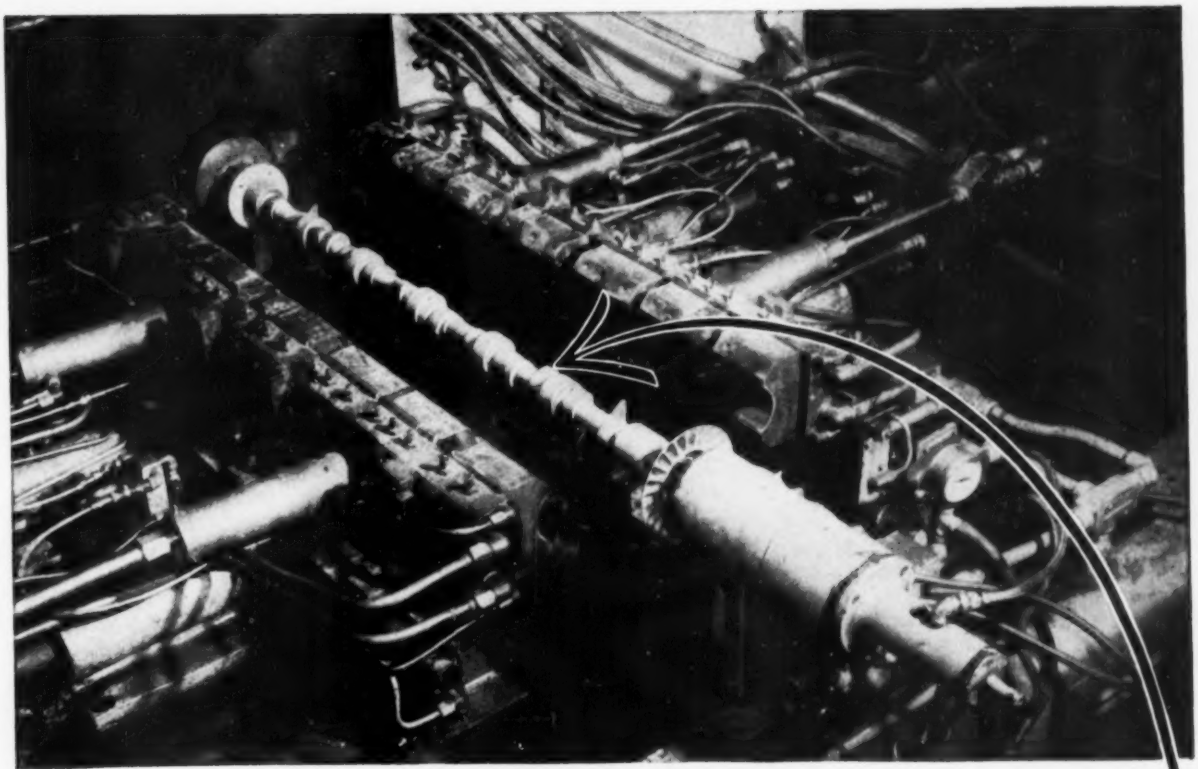
The experimental data obtained indicate that the theoretical considerations are sufficiently accurate for practical applications. The curves have also been successfully applied to problems of hardenability involving specific case-to-core ratio. The curves dealing with cylinders 3 to 5 in. in diameter have not been experimentally verified, but the opinion is that they would not deviate very greatly from the actual behavior of large cylinders. The curves are valid only for hypereutectoid steels with a critical hardness of Rockwell C-55.

Application of the calculated curves to steels with a carbon content in excess of 0.90% necessitates a pretreatment of 40 min. at 1600° F. (870° C.) followed by oil quenching prior to treating at 1450° F. (790° C.) and quenching into a well-agitated brine solution at 68° F.

Penetrations on cylinders 1 in. diameter and smaller, predicted by the hardness penetration curves based upon the cooling velocity at 1300° F. (705° C.), may be shallower than those actually obtainable due to variation of the quenching constant with bar diameter.

W. O. BINDER

*Digest of "Hardenability of Carbon Tool Steel", by Neil J. Culp, ⊕ 1954 Preprint 15.



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Strength of Zirconium at Moderate Temperatures*

THE EFFECTS of various metallurgical and test variables on the tensile properties of unalloyed zirconium are determined and then this information is used as a basis for evaluating the quantitative influence of alloying elements. Crystal-bar zirconium prepared by the iodide process was used in the experiments. The bars were cold rolled to 0.20-in. sheets at a 97% reduction. Other bars were melted in a multiple-hearth furnace and then cold rolled with a 90% reduction.

Tensile testing was done in liquid nitrogen at −195° C. (−320° F.) and in air from 25 to 370° C. (75 to 700° F.) True stress-strain, log true stress versus log true plastic strain were plotted. Yield strength, tensile strength, reduction in area and elongation are recorded.

Cold reduced zirconium was annealed at 1110° F. for ½ hr. to permit recrystallization. The cold rolled material showed a greater increase in yield and tensile strength with decreasing temperature.

The 97% cold reduced material showed unusual characteristics at 200 and 300° C. (390 and 570° F.) The maximum load was reached early in the test and then there was a long falling off till fracture occurred. Although the recrystallization temperature for this material is 750 to 930° F. (1 hr.), halts in the testing at 570° F. showed a higher load value after re-application of load. It is suggested that a combination of recovery and strain aging may cause these results.

The annealed cold reduced bars showed a yield point phenomenon. The annealed arc-melted metal showed a yield point around room temperature. This is probably due to oxygen and nitrogen impurities. Tests on the rate sensitivity showed that the annealed material was not sensitive to changes in rate of testing, but the cold reduced bar showed increased rate sensitivity with increasing temperatures.

The effects of annealing tempera-

(Continued on p. 184)

*Digest of "The Tensile Characteristics of Unalloyed Zirconium at Low and Moderate Temperatures", by J. H. Keeler, ⊕ 1954 Preprint 5.

Zirconium . . .

tures were also studied. Specimens annealed at 570 and 750° F. showed little change in tensile properties. The specimens annealed 1 hr. at 930° F. and ½ hr. at 1100, 1290 or 147° F. recrystallized to increasingly larger grains which progressively decreased the strength properties but did not greatly affect ductility and strain hardening.

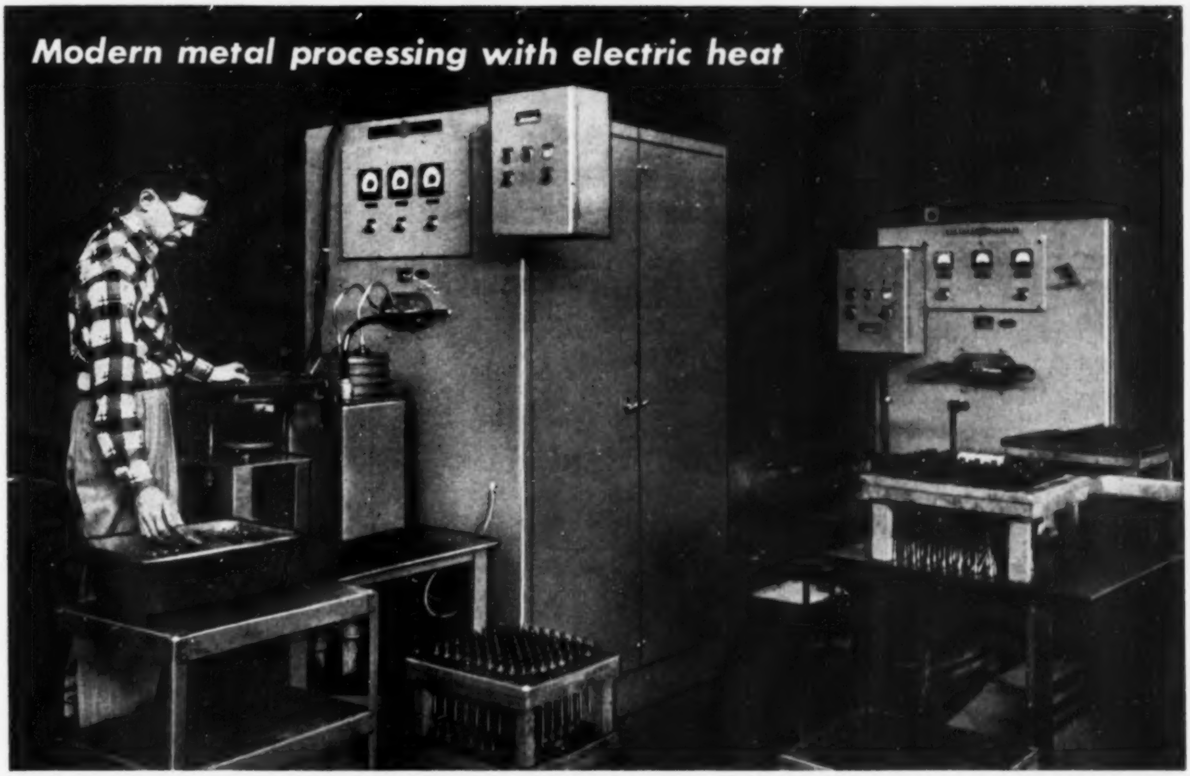
Samples that received 97% cold reduction had a strong directional texture. Weaker textures were obtained by alternate cold reduction (50%) and annealing. The 97% cold reduced zirconium was stronger and less ductile than the alternately cold reduced and annealed samples. The texture is related to the strain hardening exponent.

It is difficult to obtain high-purity zirconium by arc melting because of the affinity of the metal for oxygen, nitrogen, carbon and other elements, so the melting process must be carefully controlled. Arc melting and the accompanying nitrogen increase the hardness and strength of the metal at lower temperatures. H. C. Schneider

Deformation-Induced Martensite in Austenitic Stainless*

Stainless steels of the 18% chromium, 8% nickel type are normally austenitic at room temperature; however, martensite can be formed in these by plastic strain. Considerable work has been done on variables such as the temperature of deformation, composition, and rate of deformation. Little has been done on the martensite transformation in 18-8 stainless steels which transform on cooling. Stainless steels with low carbon and nitrogen contents exhibit such behavior. The research reported here was undertaken to obtain understanding of *(a)* the characteristics of the martensite transformation in high purity alloys of the 18-8 type which transform

*Digest of "The Effect of Deformation on the Martensitic Transformation in Austenitic Stainless Steel", by H. C. Fiedler, B. L. Averbach and Morris Cohen, 1954 Preprint 30.



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Martensite . . .

spontaneously on cooling, and *(b)* the effect of plastic deformation on the transformation in these alloys both during deformation and during subsequent cooling to subatmospheric temperatures.

Most of the work was done on vacuum melted and cast alloys. The inception and extent of transformation was determined by changes in electrical resistance. A linear relationship was found between the percentage increase in resistance at 20° C. (68° F.) and the percentage of martensite as determined by density measurements. The wire samples were elongated up to 45% by a lever device.

Carbon was found to have a strong influence on the M_s temperature. The M_s temperature is lowered approximately 10° C. (18° F.) for each 0.01% carbon. Isothermal transformation in steels having 0.006, 0.016, and 0.058% carbon was measured between the temperatures of −72 and −195° C. (−97 and −319° F.) The samples were first prequenched to −195° C. for 20 sec. and then returned to the holding temperature. The initial transformation rates are of the order of 10^{-2}% martensite per sec. in the 0.058 and 0.016% carbon alloys and 10^{-1}% martensite per sec. in the 0.006% carbon alloy.

In studies of the effect of strain on transformation, it was found that the quantity of martensite increases as the strain is increased and as the temperature of straining is lowered. The relative strain sensitivity among the alloys is consistent with their M_s temperatures and with the extent of martensite formed during cooling to −195° C. The maximum deformation of 40% elongation employed was insufficient to ascertain the M_d temperatures (M_d is the temperature above which martensite cannot be induced by deformation).

It was found that small plastic strains favor and larger strains hinder the subsequent transformation on cooling. As a first approximation the effect of strains becomes more pronounced as the temperature of straining is increased and is greatest for temperatures at which no martensite forms during the deformation. Maximum stimulation of the trans-

(Continued on p. 188)

Martensite . . .

formation is achieved by elongations of 2 to 4%. The transformation can be suppressed completely on cooling by large deformations. This is known as mechanical stabilization. Increasing amounts of deformation are required to achieve mechanical stabilization as the carbon content is decreased. It is suggested that this inhibiting effect of plastic strain is a result of the distorted or subgrain structure of the deformed austenite which may interfere with the propagation of martensite.

J. W. Spretnak

Solubility of Cerium in Alpha and Gamma Iron*

The iron-rich portion of the iron-cerium diagram was determined from thermal, metallographic, and X-ray diffraction studies. High-purity vacuum-melted iron and high-purity cerium (obtained from Iowa State College) were used. Alloys were prepared by surrounding the cerium with iron and melting in an arc under an atmosphere of helium. Arc-melted buttons containing up to 5% cerium were ductile enough to be rolled into small rectangular bars.

The solubility of cerium in both alpha and gamma iron was found to be less than 0.5% rather than the high values (12 and 15%, respectively) reported by Vogel. The alpha to gamma transformation is raised very slightly by the addition of cerium, and it is probable that the diagram is of the peritectoid type. The iron-rich intermediate phase corresponds to the composition $CeFe_5$, and it decomposes at 1940° F. (1060° C.). No evidence was found for a phase Ce_2Fe_5 reported by Vogel. The second intermediate phase is $CeFe_2$, having a face-centered cubic structure of the C15 ($MgCu_2$) type, with a = 7.302 A.

The structure of the phase $CeFe_5$ could not be determined with certainty. It probably represents a simple hexagonal lattice with an axial ratio of 0.844, and a unit cell with dimensions a = 4.900 A and c = 4.136 A.

J. L. Gregg

*Digest of "Partial Phase Diagram of the Iron-Cerium System", by James O. Jepson and Pol Duwez, 1954 Preprint 2.

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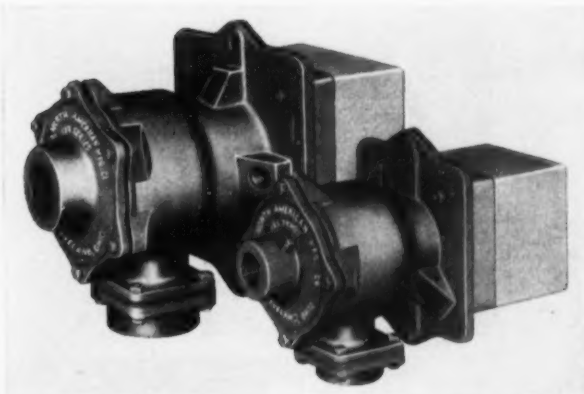

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Stress-Corrosion in Magnesium*

THIS PAPER reports an investigation of the stress-corrosion behavior at room temperature of a magnesium-base alloy (J-1) in dilute sodium chloride-potassium chromate solutions varying in pH from 3.5 to 9.0. This alloy contains nominally 6% aluminum, 1% zinc, and 0.2% manganese. Specimens were heat treated by heating at 345° C. (650° F.) for 24 hr. followed by furnace cooling or water quenching. Large grains were obtained by a strain-anneal treatment consisting of a 6% decrease in rod length followed by heating at 480° C. (900° F.).

The experimental procedure was to immerse the specimen, 3/16 x 3/16 x 4½ in., held in a fixture or holder, in the corroding medium. The specimen was stressed in bending between supports 4 in. apart by a thumbscrew at the center. A deflection of 0.120 in. was used which resulted in a nominal stress of 5,000 psi. The yield point of this material was determined to be 32,000 psi. The progress of corrosion was followed with the microscope and was recorded with a motion picture camera. A half-hour film on stress-corrosion was prepared. Corrosion currents were measured with the stressed specimen as the anode and an unstressed specimen as the cathode. In addition cathodic protection currents were applied by means of an external current source. The values of cathodic protection current to allow stress-corrosion to start and to allow stress-corrosion to restart after a crack had been formed were determined by this procedure.

It was found that heat treatment and grain size (after strain annealing) determined whether or not cracking is intergranular or transgranular, regardless of the pH of the salt-chromate corroding solution. Solution heated and furnace cooled specimens always failed intergranularly while quenched specimens always failed transgranularly. Strain annealed specimens with large grains (coarser than A.S.T.M. No. 7) failed transgranularly regardless of

*Digest of "Stress-Corrosion Mechanism in a Magnesium-Base Alloy", by D. K. Priest, F. H. Beck and M. G. Fontana, Ⓐ 1954 Preprint No. 18.

Stress-Corrosion . . .

heat treatment. The authors state that this criterion of failure may not be operative in other corrosive media because there can be different potential relationships between phases or because different electrode reactions can take place. This alloy fails transgranularly in distilled water regardless of heat treatment.

The mechanism of failure is based upon two constituents in the microstructure. One constituent, FeAl, has been reported to segregate along one certain crystallographic plane which the authors assume is the basal plane of the hexagonal close-packed lattice of this alloy. This constituent is always present regardless of heat treatment. The other constituent is $Mg_{17}Al_{12}$, which is present as a grain-boundary constituent in specimens furnace-cooled from room temperature. The presence of this precipitate in the furnace-cooled specimen accounts for the intergranular stress-corrosion observed. The FeAl constituent is said to be more cathodic to the magnesium-aluminum solid solution than the $Mg_{17}Al_{12}$, but because much more of this intergranular constituent is present in the furnace-cooled specimens, intergranular attack occurs.

The explanation of the transgranular type failure is based upon the presence of the FeAl constituent at the basal crystallographic plane. This was suggested by the fact that transgranular cracks did not always propagate in the direction normal to the applied stress but appeared to be dependent upon grain orientation. The plane along which transgranular attack took place was determined to be the (001) or basal plane of the HCP lattice. The FeAl compound is approximately one volt cathodic to the magnesium-aluminum solid solution in the salt-chromate solution.

Motion picture studies showed that plastic deformation takes place continuously at the tip of an advancing transgranular crack. This deformation is said to prevent any film formation and thus allow a potential difference to be maintained between filmed and film-free surfaces. Only a small cathodic current is required in order to prevent stress-corrosion. A. H. RAUCH

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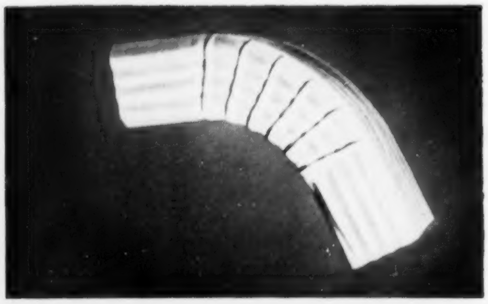

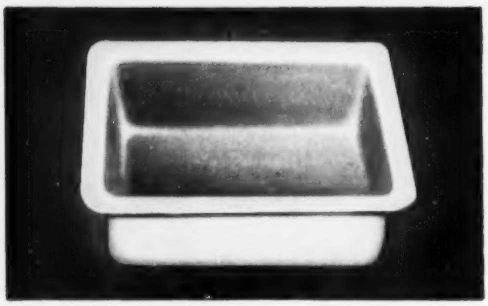

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Microstructural Changes in Fe-C Alloys*

It was learned in an earlier work conducted by these authors that tempering at low temperatures (in the range of room temperature to 700° F.) caused the ϵ-carbide to dissolve and to form as a film at the martensite grain boundaries, and cementite to form as platelets and globules within the martensite grains. In this continuation of that work, the study was devoted to carbide morphology, ferritic grain growth, rates of softening, and completion of the third stage of tempering which takes place in the range of 700° F. to Ac_1. Four plain carbon steels of 1.4, 0.80, 0.40, and 0.15% carbon were used.

Tempering at successively higher temperatures within this range eventually causes all of the cementite to form a grain-boundary film. It forms at the ferrite grain boundaries and then later develops at the prior austenite grain boundaries. The speed of its formation is increased as carbon content is decreased. It persists even after spheroidization.

The ferrite grain of the quenched and quenched and tempered steels is small, so a special technique was used to measure the grain size. For easy comparison the results have been converted to approximate A.S.T.M. grain-size numbers. It was found that the ferritic grain size is finer that the prior austenite grain size, and that the grains retain the acicular shape of the martensite, and grow slowly in the temperature range of 900 to 1300° F. because of the inhibiting effect of the grain-boundary cementite.

The location of cementite at the grain boundaries of the ferrite is accounted for by the lower interfacial energy between the ferrite and cementite than between the individual ferrite grains. These interfacial energies were used in the determinations of the minimum size of cementite particle that would be stable and favored over the cementite film at the grain boundaries. This minimum size increases with the carbon content and the ferritic grain size.

(Continued on p. 196)

*Digest of "Further Study of Microstructural Changes in Tempering Iron-Carbon Alloys", by B. S. Lement, B. L. Averbach, and M. Cohen, 1954 Preprint 21.

Microstructural Changes

In the 700 to 1000° F. range the factors that are thought to affect softening area are: *(a)* decrease in the carbon content of the matrix, *(b)* solution, spheroidization and coalescence of the cementite particles within the prior martensite plates, and *(c)* spheroidization and coalescence of cementite at the boundaries of the martensite plates. These softening effects are opposed by a hardening effect which is caused by the formation and extension of the cementite films at the prior martensite boundaries.

The solubility of carbide in ferrite during tempering is considered as a function of the particle size parameter. Parameters are calculated for five different shapes of carbide particles. Electron microscope observations show cementite platelet thickness and globule radii to vary from 10^{-6} to 10^{-5} cm. With a thin lenticular platelet this gives a size parameter of 5×10^{-7} cm. It is possible that cementite particles of this size parameter with a carbon content of 7.7% C could be dissolved in a pure ferritic matrix.

It is thought that a change in the carbon content of the cementite during tempering occurs and that this change influences the carbon content of the matrix, by enhancing the solubility of the carbon on account of the presence of small coherent particles of cementite with a composition that may differ from the formula Fe_3C.

H. C. SCHNEIDER

Strength of Low-Carbon Martensites*

LOW-CARBON martensites (0.11 to 28% C) were studied to obtain information which could be used in the development of steels having high strength but with better ductility and toughness than that of steels containing 0.30% or more carbon. It was known in general that low-carbon martensites are tougher, but quantitative data were

(Continued on p. 198)

*Digest of "Tensile and Impact Properties of Low-Carbon Martensite", by C. C. Busby, M. F. Hawkes, and H. W. Paxton, ⓐ 1954 Preprint No. 9.

Low-C Martensites . . .

needed on the effect of carbon content on ductility and toughness of both untempered and tempered martensites.

Thirty-eight steels were evaluated; all were fine-grained, aluminum-killed steels made in basic electric and induction furnaces. Specimens for the tensile tests were 0.252 in. diameter and those for the impact tests were standard V-notch charpy specimens. The specimens were finish-machined and austenitized.

The majority of the steels showed very small amounts of tensile ductility in the as-quenched condition. A relatively short tempering treatment at 210° F. (100° C.) improved all of the mechanical properties of the steels except the tensile strength of steels with lower carbon contents. To attain maximum improvement by tempering at 210° F., 4 hr. at temperature is sufficient for the lower carbon steels, but the higher carbon steels require up to 12 hr. The yield: tensile ratio is relatively low (0.70: 0.80) in the as-quenched condition and is improved only slightly by tempering at 210° F. The reduction of area and elongation values are improved by the tempering treatment, especially in the higher carbon steels. On the average, the reduction of area at a given tensile strength is 13% higher for the lower carbon steels as compared to steels with over 0.30% carbon.

The amount or type of alloying elements studied (other than carbon) has essentially no effect on ductility. Also, refrigeration in liquid nitrogen produced no significant change in mechanical properties. The major cause of improved ductility resulting from tempering at 210° F. was not isolated and evaluated. The tensile properties of specimens ranging in size from 0.252 to 0.505 in. diameter, except for yield strength, are essentially the same. Yield strength decreases with increasing section size.

Impact strength versus testing temperature curves were obtained for all steels in the as-quenched, and quenched and tempered conditions. The majority of steels had impact strengths at room temperature that were higher than those of steels with higher carbon content (0.30% to 0.40% carbon) and

quenched and tempered to comparable hardness. Tempering at 210° F. usually raises the impact strength at all testing temperatures and slightly lowers the transition temperature. The effect of alloying elements on impact properties was studied. Nickel is most beneficial in lowering transition temperature; chromium up to 2% lowers the transition temperature to some extent, whereas manganese between 0.8 and 1.5% significantly raises transition temperature.

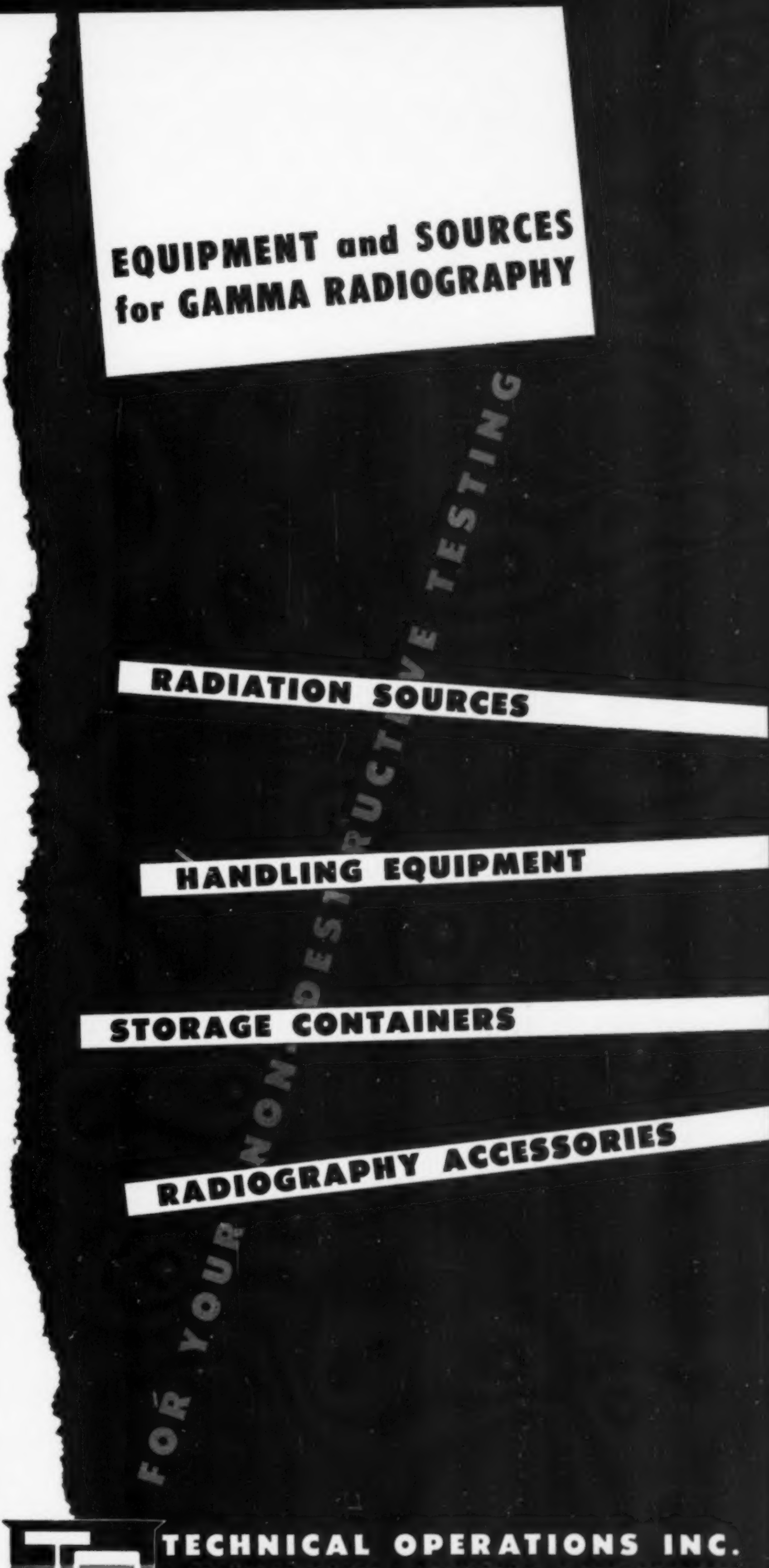
In an attempt to improve the yield-tensile ratio, the effect of strain aging on this ratio was evaluated. All the steels showed aging effects, the amount of which depended on the amount of deformation and the aging temperature. Strains amounting to 5 to 13% reduction in area increase tensile strength up to 34,000 psi. with only a slight decrease in reduction of area. The elongation is greatly reduced and the yield-tensile ratio is one for all steels. A limited amount of data indicate that strain aging lowers impact strength and slightly raises the transition temperature.

J. W. SPRETNAK

Transformation of Ordered Structures*

THE copper-gold alloy system is the prototype of a group of systems which are isomorphous at high temperature and which undergo ordering transformations at lower temperature. It is generally accepted that two types of ordered structures are formed, one ideally having equal numbers of atoms of the two metals and being referred to as the CuAu type, the other ideally having three copper atoms for every gold atom and being called the Cu_3Au type. The former has tetragonal crystal symmetry, the latter face-centered cubic; both transform into an isomorphous face-centered cubic disordered solid solution at higher temperature. There is general agreement also that ordering is not confined to the alloys of ideally stoichiometric composition, but occurs in the copper-gold system in the range from

*Digest of "Constitution of Ordering Alloys of the System Copper-Gold", by F. N. Rhines, W. E. Bond, R. A. Rummel, 1954 Preprint 6.



about 18 to approximately 70 at. % gold, or higher.

There have been a number of investigations of the copper-gold system, but a broad range of intermediate alloys remains whose constitution is imperfectly established and whose transformation characteristics remain almost unstudied. Within this range lies a disputed "intermediate ordering phase", near 41 at. % gold. Further knowledge of these alloys is desirable, both to extend the understanding of the ordering characteristics of nonstoichiometric alloys, and because of a growing technical interest in the heat treatment of analogous alloys.

Accordingly, the present studies consisted in a re-examination of the constitution of 24 ordering alloys covering the range 19.5 to 70 at. % gold. The technique for insuring the attainment of equilibrium consisted in measuring the electrical resistance at a sequence of constant temperatures, after sufficient time had elapsed, and proving equilibrium by repeating the process, but approaching equilibrium from the opposite direction.

The alloys were prepared as 10-g. charges of the purest available grades of electrolytic gold and oxygen-free electrolytic copper, sealed under a partial atmosphere of purified argon in silica glass capsules lined with "Aquadag". The alloys were remelted several times to get complete mixing. After annealing, and cold forging with intermediate annealing, the alloys were die-drawn to 0.017 in. diameter, and given a final anneal before test.

The following conclusions were drawn:

1. By means of measurements made at equilibrium, the ordus and disordus boundaries of the system copper-gold have been relocated and the existence of such conjugate boundaries has been proved; a new phase diagram is presented.

2. A eutectoid transformation (disordered to ordered CuAu and ordered Cu_3Au) occurs at about 36 at. % gold and 284° C. (543° F.)

3. The existence of a field of coexistence of the ordered phases Cu_3Au and CuAu, between about 35 and 40 at. % gold, has been demonstrated.

4. There is no evidence of an intermediate phase at 41 at. % gold,

(*Continued on p. 202*)

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Ordered Structures . . .

such as had been postulated by Haughton and Payne.

5. Evidence exists of the occurrence of another phase near 70 at. % gold; this phase seems to have higher electrical resistivity than the conjugate disordered phase at like temperature.

6. A copper-gold alloy, containing 66 at. % gold, exhibits a nearly zero temperature coefficient between 240 and 270° C. (464 to 518° F.) and a very small coefficient at higher temperatures.

7. Ordering in the copper-gold system proceeds in a manner typical of phase changes that occur by nucleation and growth processes.

G. V. Smith

Influence of Nitrogen in Cr-Mn-Ni Steels*

This investigation of chromium-manganese-nickel steels containing nitrogen was prompted by the need for nickel conservation, and at the same time as an aid in expanding the utilization of stainless steels. The authors' primary objective was the study of the influence of nitrogen upon the structure and properties of chromium-manganese-nickel steels. Such an objective was justified by the known beneficial effects of nitrogen upon hot workability and upon austenite stability in steels of this type.

The work was conducted on a series of steels containing 12 to 18% chromium, 1 to 20% manganese, 0 to 4% nickel, 0.05 to 0.15% carbon, and with nitrogen contents between about 0.12 and 0.18%. The steels were induction melted and cast into 2-in. square ingots weighing approximately 17 lb. These were hot worked at 2100 to 2145° F. into ¼ and 1/16-in. thick strips, solution heat treated 15 min. at 1965° F. and air cooled prior to testing. All specimens were examined magnetically (and some metallographically) for the presence of delta ferrite. Hardness, tensile, impact and Erich-

(Continued on p. 204)

*Digest of "Austenitic Chromium-Manganese-Nickel Steels Containing Nitrogen", by Russell Franks, W. O. Binder and James Thompson, © 1954 Preprint 29.

Nitrogen . . .

sen cupping tests were made on appropriate specimens.

Results of the investigation indicate that the austenitic region is greatly restricted by increasing chromium contents and expanded by raising the nickel content. Manganese in excess of 8% expands the delta ferrite-austenite region when chromium is in excess of 15%, this value being the maximum chromium content in which a fully austenitic structure can be produced by manganese alone. It was also observed in these low-carbon steels containing 15% or more chromium that the austenite-forming capacity of manganese is weak, and that it acts primarily as an austenite stabilizer rather than as an austenite former.

Both nitrogen and carbon were found to expand the austenitic region in these steels and it was concluded that they are more potent than nickel in this respect. Of the two, carbon is somewhat stronger.

It was found that greater amounts of nickel and nitrogen were required to produce fully austenitic structures in the as-cast condition than in the hot-worked condition. The homogenizing action of hot working is probably responsible for this difference. It is desirable to adjust the composition to obtain a substantially austenitic structure in the as-cast condition in order to avoid subsequent hot working difficulties caused by the presence of too much delta ferrite. The composition limits recommended by the authors for steels meeting this requirement are as follows: 16.0 to 17.5% chromium, 3.5 to 4.5% nickel, 7.0 to 9.0% manganese, 0.06 to 0.10% carbon, and 0.12 to 0.18% nitrogen.

Steels within these limits had good hot working properties if the initial working temperature was kept at a maximum of 2235° F. These steels also showed good mechanical properties in the hot worked and solution treated condition. The mechanical properties for steels solution treated at 1965° F. were comparable with those of the conventional austenitic chromium-nickel steels, and their work hardening characteristics were between those of 17% Cr, 7% Ni, and 18% Cr, 9% Ni steels. Steels within the recommended composition limits

(Continued on p. 206)


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Nitrogen . . .

had good welding characteristics and the welds showed high toughness at room and subzero temperatures. The stabilizing effect of manganese on austenite was found to be particularly helpful in retarding notch-sensitivity at low temperatures. General corrosion resistance of these steels in oxidizing environments was comparable to that of 17% Cr, 7% Ni steel.

W. W. Austin

Mechanical Properties of Ductile Irons at Elevated Temperatures*

Cast irons with spheroidal graphite, variously termed ductile, nodular, spheroidal or spherulitic graphite irons, have become recognized standard materials during the past four years. Considerable research, engineering and field testing have supplied the essential knowledge for substantial and increasing commercial production for a wide range of applications. The ductile cast irons combine many of the processing or foundry handling qualities of gray cast irons with mechanical property characteristics approaching those of the annealed or normalized cast carbon steels.

Published data that show the superior resistance to growth and oxidation of ductile irons over flake irons suggest possibilities for elevated-temperature service. However, data on the mechanical properties at elevated temperatures are scant, particularly on long-term creep. This paper gives "general base-line data" on the creep and stress-rupture properties of three types of ductile irons, together with tensile proporties at room and elevated temperatures and data on their growth.

A number of heats of each of three types of ductile irons, namely ferritic, pearlitic, and austenitic, were studied. Nominal compositions were as follows:

(Continued on p. 208)

*Digest of "Elevated Temperature Properties of Ductile Cast Irons", by C. R. Wilks, N. A. Matthews and R. W. Kraft, Jr., 1954 Preprint No. 34.

Ductile Irons . . .

	F*	P*	A*
Carbon	3.7	3.7	3.0
Manganese	0.4	0.4	2.0
Nickel	1.0	1.0	22.0
Magnesium	0.07	0.07	0.08

All of the heats which were extensively studied were made by basic induction practice. Pig iron, mild steel punchings and ferro-alloys constituted the charge, except for two austenitic iron heats where 50% shop returns were used. Heat sizes ranged from 100 to 1000 lb. The furnaces were tapped at approximately 2700° F., and treated with a proprietary nickel-magnesium alloy with the subsequent addition of 1% silicon as 85 grade ferrosilicon on reladling in accordance with the practices defined in the patents of the International Nickel Co. Test bars were also obtained from six heats of ferritic ductile iron which were produced in a basic (magnesite) lined cupola. Testing followed in general the applicable A.S.T.M. procedure.

The short-term tensile and rupture properties of pearlitic ductile iron were found to be superior to those of the ferritic grade. Correspondingly, superior creep properties, reflecting long-term behavior, held only to about 800° F. At higher temperature the potential long-term superiority cannot be realized because the pearlitic iron, structurally unstable, progressively graphitizes and reverts to a ferritic iron which has lower creep strength than the standard ferritic grade. Creep strength of the stable ferritic iron is comparable to that of low-carbon steel from 800 to 1200° F.

The austenitic iron was markedly stronger at and above 1000° F. than the ferritic and pearlitic grades, which lose strength rapidly above 800° F. The utility of the standard ferritic and pearlitic grades appears limited to a maximum temperature of 1000 to 1100° F. for long-term load-carrying applications when both scaling resistance and strength are considered. The high-nickel austenitic iron should have similar utility to 1200 to 1300° F.

G. V. SMITH

*F is a ferritic steel, annealed; P is pearlitic, normalized; A is austenitic, not heat treated. In all three steels phosphorus and sulphur were low, and silicon was 2.5 to 2.6%.


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Influence of Static Stress on Damping Capacity*

Damping capacity is important in preventing high stresses developing at or near resonance. Much data have been collected on damping capacity of various metals and alloys, but the effect of static stress on damping has been largely neglected. An example of static stress is in members which are subjected to large centrifugal stresses, such as turbine or compressor blades.

Damping capacity measurements were made on wires on which various weights were suspended. Wires of A.I.S.I. 403 (ferromagnetic stainless steel) and Refractaloy 26 (nonferromagnetic high-temperature alloy) were used in this study. Theoretical considerations indicate that at low vibrational stresses, the damping behavior will depend on whether the material is ferromagnetic or nonferromagnetic. In making the tests, the wires were silver-soldered at both ends into ⅜-in. diameter brass rods. The top end of the fixture is rigidly mounted, whereas the bottom part is free to rotate. The static stress is obtained by placing lead weights on the bottom of the fixture. An inertia arm with variable weights is soldered on the bottom end of the fixture. After twisting the wire, the decay of vibrational torsion is measured optically. The static stress is varied by suspending different weights from the brass rod, and vibrational stress is changed by increasing the amount of twist. A solenoid is provided to differentiate damping due to plastic flow and due to magneto-mechanical hysteresis.

Static stresses in the range 910 to 51,000 psi. and a vibrational torsion stress range of 0 to 40,000 psi. were employed. Measurements in the range of 70 to 1300° F. were made. The results were in accord with theoretical expectations. For the ferromagnetic material (A.I.S.I. 403) at low torsional strains, the damping capacity first increases, then decreases with increasing applied stress. At larger torsional stresses, damping capacity increases directly with the applied stress. At elevated temperatures, the damping curves at 750° F. are basically the same as at room temperature. At higher temperatures, not only does damping rapidly increase, but the direction of the effect of static stress reverses. The nonferromagnetic (Refractaloy 26), to the contrary, exhibits a simple relationship among static stress, shear strain, and temperature. Its damping increases with these three quantities in a continuous fashion throughout the entire range of applied stress and temperature. In addition, its damping capacity is considerably smaller than that for the ferromagnetic material.

The curves obtained are rationalized in terms of strain-hardening, recovery and magneto-mechanical hysteresis. Damping in ferromagnetic materials in the range of stress employed has two basic causes: magneto-mechanical hysteresis and plastic flow. The former is predominant

(Continued on p. 212)

*Digest of "Effect of Static Stress on the Damping of Some Engineering Alloys", by A. W. Cochardt, © 1954 Preprint 26.

Damping Capacity . . .

at lower torsional stresses whereas the latter is predominant at higher stresses. A static stress causes magneto-mechanical damping to decrease gradually and finally disappear. The influence of static stress on plastic flow damping is complex. It is observed that damping first increases with static stress, but then it may decrease if considerable strain hardening takes place during the vibration. The effect of temperature can be interpreted through its effect on strain hardening and recovery.

J. W. SPRETNAK

Phase Equilibria in the Ti-Al-Mn System*

THE PHASE equilibria of the titanium-rich corner of the titanium-aluminum-manganese system were investigated on alloys that extended in composition up to the two binary intermediate phases TiAl and $TiMn_2$. More than 100 alloys were prepared from iodide titanium (99.97% Ti) which was the basis metal, aluminum (99.99% Al), and refined electrolytic manganese. The alloy buttons were prepared by arc melting in a nonconsumable electrode furnace using inert atmosphere protection. After homogenizing for 24 hr. at 1830° F., the samples were sealed in Vycor or quartz bulbs and were annealed for a period that varied from 2 hr. at 2370° F., to 400 hr. at 1290° F. Annealing temperatures of 1290, 1380, 1470, 1560, 1650, 1740, 1830, 2010 and 2190° F. were used to explore the solid-state equilibria. After quenching the samples to retain the equilibrium structures, metallographic examination was used to establish the nine isothermal regions of the phase diagram at the temperatures just listed. These regions were then used to construct vertical sections at 90, 80, 70 and 60% Ti and at 5 and 10% Mn, which are reproduced in the paper along with six isothermal sections.

The phase fields α, β, $(\alpha + \beta)$, $(\alpha + \beta + \text{TiAl})$, $(\beta + \text{TiAl})$ and

(Continued on p. 214)

*Digest of "The System Titanium-Aluminum-Manganese", by R. F. Domagala and W. Rostoker, ASM 1954 Preprint 4.

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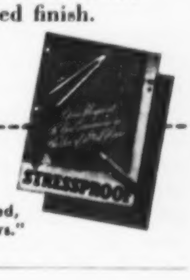

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Ti-Al-Mn System . . .

$(\beta + TiAl + TiMn_2)$ were established at elevated temperatures. The $\beta + TiAl$ field narrowed with progressively lowered temperature and disappeared at 1589° F. (865° C.) where a four-phase reaction of the Type $\beta + TiAL \rightleftarrows TiMn_2 + \alpha$ occurred. Typical microstructures of alloys that are susceptible to this reaction are shown. A second four-phase reaction proposed is $\beta + TiMn_2 \rightleftarrows \alpha + TiMn$.

Contours for the β-phase field and for the solidus surface are shown in the corresponding graphs. The latter were obtained by a graphical method from data for 28 alloys using the incipient melting technique. Observations were made with an optical pyrometer of the temperature at which sharp corners of small specimens started to round or collapse on heating. The authors recognized that this method yields only an approximation of the solidus temperature and that volatilization of manganese from some alloys might provide measurements on the high side. In the range of composition investigated the melting temperature decreased progressively away from the titanium-rich corner.

A. H. GEISLER

Secondary Graphite in Ductile Iron*

THIS PAPER presents evidence to substantiate a theory of the mechanism of secondary graphite formation in spheroidal graphite cast irons. The theory is that the martensite of quenched ductile irons decomposes upon tempering into ferrite and two types of carbides – iron carbides and silicon-rich iron carbides. Concurrently or immediately after the decomposition of the martensite to ferrite and carbides, the silicon-rich carbides decompose or graphitize to form minute secondary graphite spherulites, which subsequently grow in size. The amount of secondary graphite is related to the amount of silicon-rich carbides that are formed from the martensite and this in turn is related to the silicon content of the iron. Chromium appears to retard the formation of secondary graphite (by decreasing the amount of silicon-rich carbides formed). The secondary graphite appeared to be quite stable.

Metallographic examination of six quenched and tempered ductile irons revealed that no secondary graphite was formed at temperatures below 1000° F. and for times less than 2 hr. At higher temperatures secondary graphite was observed and the particles were more abundant and larger at progressively higher tempering temperatures.

Photomicrographs of the same fields under bright-light and under polarized light indicate that the secondary graphite nodules, and the carbides from which they are derived, occurred only in the dendritic cores. These carbides and the graphite exhibited an optical cross under polarized light. The carbides which were mainly unaffected by the tempering treatment exhibited no optical cross under polarized light

*Digest of "Secondary Graphitization of Quenched and Tempered Ductile Cast Iron", by J. C. Danko and J. F. Libsch, Ⓜ 1954 Preprint 32.

and were concentrated principally in the interdendritic areas.

The authors show, by an extensive literature survey, that silicon-rich carbides are known to exist, that they exhibit an optical cross under polarized light, they do not respond to heat treating, and that they graphitize readily. The opposite is true of iron carbides.

Heat tinting experiments added weight to the theory which is summarized alongside.

R. W. KRAFT

Nature of Martensite Decomposition Product

	IRON CARBIDES	SILICON-RICH CARBIDES
Occurrence	Interdendritic areas	Dendrites
Time of formation	Last, usually highly alloyed	First to form
Characteristics under polarized light	No cross	Exhibit optical cross
Response to heat tinting	Darkened	Unaffected
Effect of tempering	Tend to remain stable	Decompose or graphitize to secondary graphite
Analysis effects	Chromium enhances formation	Silicon enhances formation

Effect of Heat Treatment on Behavior of a Cobalt-Base Alloy*

THE cobalt-base alloy studied was wrought Stellite 21, containing 0.29 C, 28.75 Cr, 3.01 Ni, 5.52 Mo, 0.33 Fe, 0.44 Si, 0.56 Mn, and 61.10 Co. Specimens were solution heat treated by holding at 2250° F. for 72 hr. and then quenching in water. This treatment produced a solid solution showing few or no residual precipitates, and having a grain size 10 to 20 times larger than A.S.T.M. No. 1. Hardness after solution treating was about Rockwell C-21.

Isothermal transformation of the solution treated samples at temperatures of 1950, 1750, and 1500° F. resulted in the formation of pearlite along grain boundaries. Both the quantities of pearlite and the interlamellar spacing decreased with decreasing temperature. Widmanstätten structures formed by isothermal transformation at temperatures as high as 1750° F. At 1500° F., Widmanstätten precipitation predominated over pearlite formation. A small amount of precipitate was visible following the isothermal transformation at 1200° F. in 72 hr.

Aging the solution treated and water quenched material at temperatures from 1200 to 1950° F. resulted in precipitation principally along slip lines and twin boundaries, the slip lines having resulted from the water quench. With sufficiently prolonged times of aging or isothermal transformation, spheroidization

*Digest of "Effect of Heat Treatment Upon Microstructures, Microconstituents and Hardness of a Wrought Cobalt-Base Alloy", by J. W. Weeton and R. A. Signorelli, 1954 Preprint 39.

and agglomeration of precipitated carbide particles occurred at temperatures as low as 1500° F. This occurred more rapidly in structures formed by aging than by isothermal transformation.

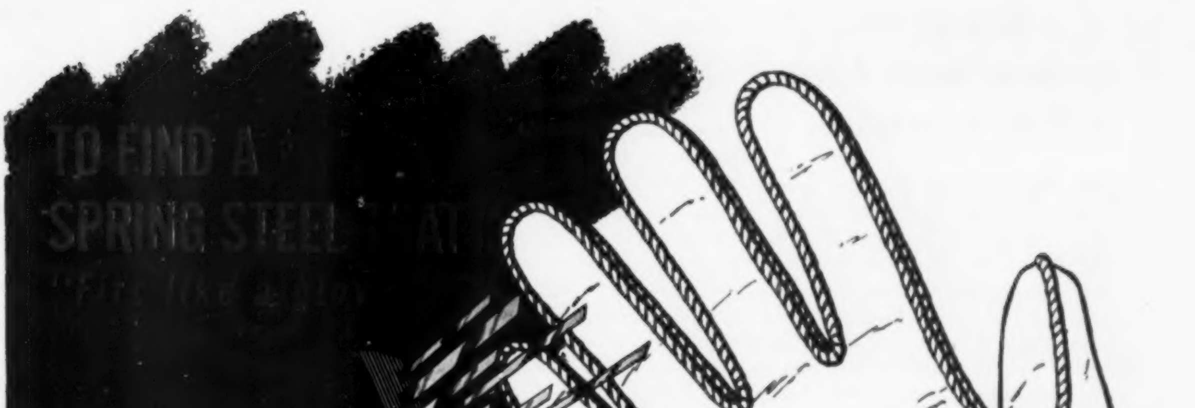
The solution treated samples that were aged between 1400 and 1500° F. for 72 hr. had a maximum hardness of Rockwell C-42. Maximum hardness obtained from the isothermal transformation treatment was about Rockwell C-40, and was developed between 1500 and 1600° F.

Hardness was not increased by aging or isothermal transformation at 1200° F. Specimens aged at 1500° F. and those isothermally transformed at 1500 and 1750° F. continued to harden up to 72 hr. Overaging or softening occurred within 72 hr. at 1750° F. and above for aging, and at 1950° F. for isothermal transformation. Aging the solution treated and water quenched material generally resulted in a more rapid increase in hardness than isothermal transformation at the same temperature.

X-ray diffraction methods indicated that $Cr_{23}C_6$ was the residual carbide in the wrought alloy. In heat treated specimens this carbide appeared to be the most prevalent, although M_6C was also usually present. Sigma found in the heat treated specimens was thought to form in conjunction with, or subsequent to the formation of $Cr_{23}C_6$. X-ray diffraction results coupled with metallographic examination of stain etched and heat tinted specimens indicated that one of the two phases of the pearlite was predominantly $Cr_{23}C_6$. The M_6C carbide was also detected in many specimens, and it possibly formed from the transformation of the $Cr_{23}C_6$ lamellae.

Relative quantities of the matrix phases of specimens given various heat treatments were estimated from X-ray diffraction patterns. The matrix consisted of the face-centered cubic structure after solution treatment at 2250° F. At 1950° F., short transformation times of ¼ to 2 hr. did not cause transformation of the matrix to the hexagonal close-packed structure. At 1500° F., short transformation times produced large quantities of the hexagonal phase. Holding for 72 hr. at 1500 and 1950° F. converted almost all of the matrix to the hexagonal phase.

J. L. Gregg



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Strength of Zirconium Binary Alloys at High Temperatures*

THE melting point (3325° F.) of zirconium makes this metal attractive for high-temperature service, either in noncorrosive media or with suitable protective cladding. Because zirconium has relatively poor mechanical properties at elevated temperatures, the possibility of improvement by alloying is of considerable interest. This paper describes an investigation that was undertaken to determine the effectiveness of alloying in increasing the strength of zirconium in the range of 1800 to 2200° F.

At temperatures of 1800 to 2200° F., it appeared unlikely that much precipitation hardening could be expected and that strengthening would have to be of the solid solution type. Selection of the zirconium binary alloy systems for initial investigation was decided on the basis of known solid-solution alloying characteristics, solid-solution alloy theory, the results of zirconium alloy tests at lower temperatures, and such pertinent primary properties as melting points and high-temperature strength. Elements selected for alloying additions to zirconium were chromium (up to 30% by weight), columbium (up to 40%), molybdenum (up to 40%), tantalum (up to 50%), tungsten (up to 20%), and vanadium (up to 40% by weight).

This study consisted of five phases: preparation of the binary alloys by melting; rolling the alloys to sheet at 1850 to 2200° F; hardness testing at room temperature and 1600° F; short-time rupture-strength determinations at 1800, 2000 and 2200° F. in helium; and creep-rupture testing of the most promising alloy at 1800° F. in vacuum.

The zirconium-base alloys were melted in a helium atmosphere in arc furnaces using nonconsumable (tungsten) electrodes and power sources of about 500 and 1000 amp. Water-cooled copper-block crucibles of 7.5 and 32 cc. capacity were used to melt the alloys, which were cast into small rectangular ingots in two sizes for rolling and hardness tests, and for short-time stress-rupture tests, respectively. Charges of 50 to 75 g. were generally melted four to six times to attain homogeneity, and then melted together where larger ingots were needed, as in the fabrication of short-time rupture specimens. Alloys of zirconium-molybdenum and zirconium-tungsten were the most difficult to produce. Increasing the current and the number of remelts resulted in increased homogeneity of the zirconium-molybdenum alloys. Alloying of zirconium and tungsten was improved by charging tungsten powder and stacking pieces of nibbled zirconium around it in the crucible. On partial melting at relatively low current, the powder was gathered by the molten zirconium. Homogeneous alloys were prepared after several remelts.

Tungsten was found to be a very effective strengthener for zirconium in the temperature range 1800 to 2200° F. Zirconium-tungsten alloys can be readily hot worked, but care is required to produce homogeneous alloys by arc melting. Comparison with commercial alloys in this temperature range shows that zirconium-tungsten alloys approach the strength properties of Inconel alloy or Type 310 stainless steel at 2200° F.

(Continued on p. 220)

*Digest of "The Strength of Wrought Zirconium-Base Binary Alloys at 1800 to 2200° F.", by H. A. Saller, J. T. Stacy and S. W. Porembka, 1954 Preprint 37.

Zirconium Alloys . . .

Binary additions of chromium, columbium, molybdenum, and tantalum also strengthen zirconium at 1800 to 2200° F., but to a less extent than does tungsten. With the exception of tantalum, these elements and vanadium will markedly reduce the workability.

Molybdenum, tungsten and chromium are more effective in strengthening zirconium at 1800 to 2200° F. than are vanadium, tantalum and columbium. For a given group, the heavier the metal, the better as a strengthener, and the less it reduces hot workability. G. V. SMITH

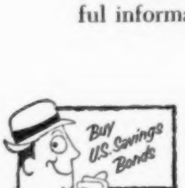
Fatigue Properties of Lamellar and Spheroidal Carbides*

PLAIN carbon eutectoid steels with coarse pearlitic and spheroidized structures were used to study the effect of carbide morphology on fatigue properties. The fatigue specimens (5 in. long and 0.30 in. minimum diameter) were tested on Moore rotating beam machines at speeds between 8,000 and 10,000 r.p.m. The machines were equipped with a setscrew device which actuated a relay to stop the test when a small change in the deflection of the specimen occurred, the specimens being run until they cracked. The cracks varied in size from one not visible without a microscope to one about a quarter of the way through the diameter. The tests showed that there was no significant difference between this criterion of failure and complete fracture.

Approximately 20 specimens were tested at each stress level for each structure. The severe heating of the specimens at stresses above 47,500 psi. limited the range that could be studied. Even when the specimens were rotated at 4500 r.p.m., the generation of heat was pronounced. In the finite life region of the S-N curve the mean of the distribution of log N, its standard deviation σ, the

(Continued on p. 222)

*Digest of "The Statistical Fatigue Properties of Lamellar and Spheroidal Eutectoid Steel", by G. E. Dieter, R. F. Mehl and G. T. Horne, ⊛ 1954 Preprint 25.



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Fatigue . . .

standard error of the mean log N, and the relative standard deviation V, were calculated at each stress from the 20 observations of fatigue life. It was assumed in all instances that the distribution of fatigue life at constant stress was adequately represented by the logarithmic normal distribution. In the endurance range 20 specimens were tested at each stress level and the mean fatigue limit, $\overline{S}$, and its standard deviation were determined from the percentage of failures at each stress using the probit method. The criterion for a nonfailure was taken as 2.5×10^7 cycles, although several specimens were run at 5×10^7 cycles to note any tendency for delay failure.

When the F test for a significant difference in the variability of two sets of data was applied to the standard deviations for each structure at a series of stresses, the scatter in fatigue life was found to increase significantly with decrease in stress.

The S-N curves show that the mean fatigue limit of the pearlite structure is much lower than that of the spheroidized structure, despite the fact that both steels had almost identical tensile strengths; the pearlitic material had less scatter in both the finite life range and the fatigue limit. Although the mean free finite path appears to be the chief factor determining the static tensile properties of a steel, it does not determine the fatigue properties.

The distribution of the point of failure was about the same for both structures. A large number of specimens failed away from the point of minimum diameter. This would indicate that the carbide second phase is not the primary cause of crack initiation. Rather, it is believed that the initiation of fatigue fracture is primarily caused by inclusions. Metallographic evidence appeared to substantiate this conclusion.

It is believed that the primary influence of the carbide phase is in modifying the stress distribution existing in the ferrite matrix through stress concentrating effects. The thin lamellar carbides in the pearlite structure act as more severe stress concentrators than the spheroidal carbides in the spheroidite structure.

J. E. Stukel

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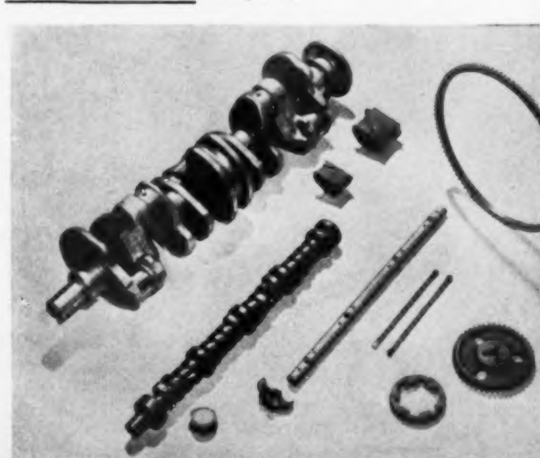

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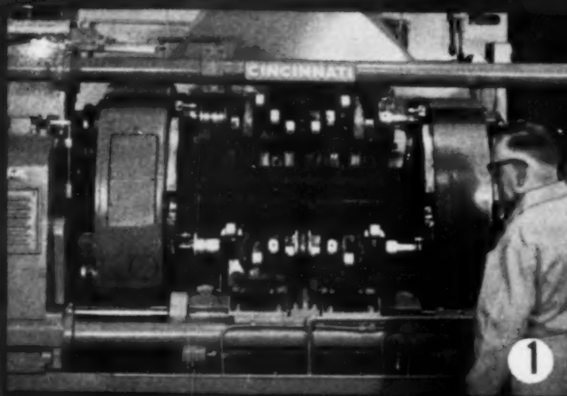
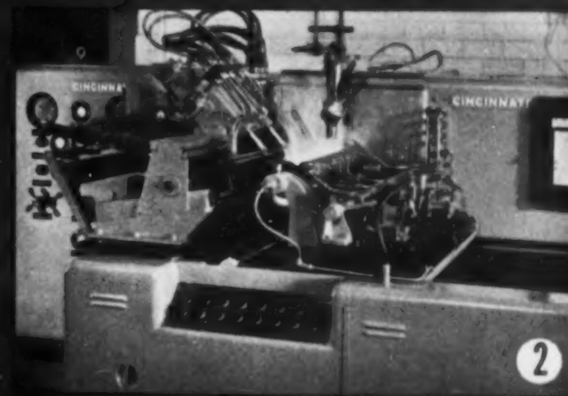
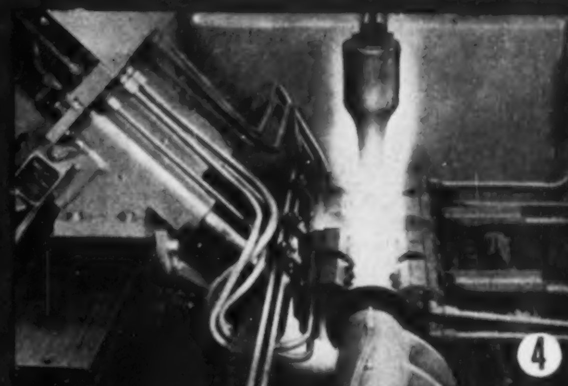




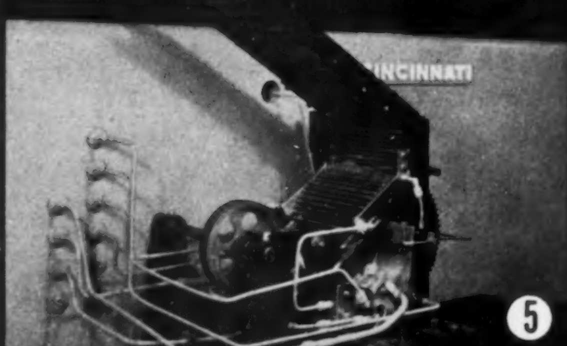
Flamatic selectively hardens [illegible] and main bearings of crankshafts.

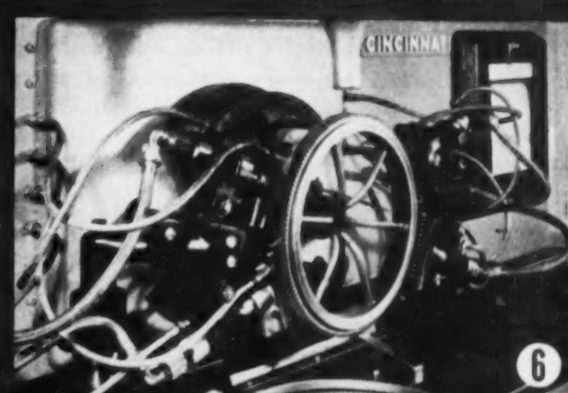
Selective hardening [illegible]



[illegible] Flamatic selectively hardens [illegible] simultaneously while operator loads other station.

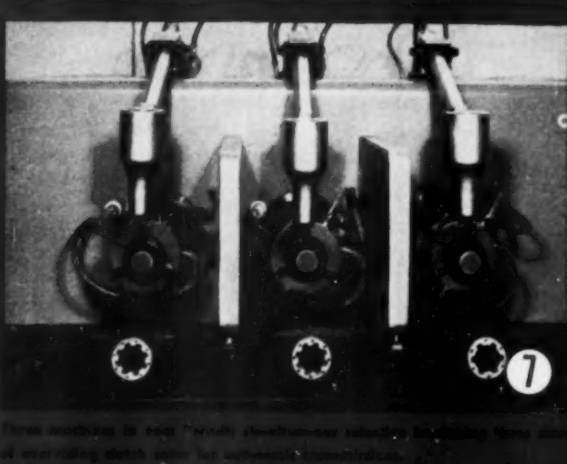
Selective hardening [illegible]

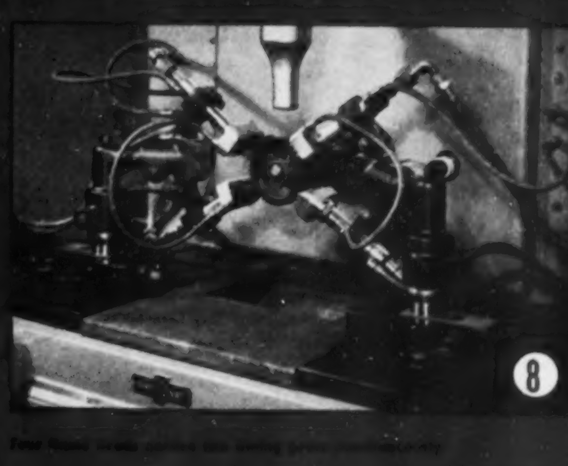




[illegible] type flame heads permit continuous selective hardening of push rods.

Two-at-a-time Flamatic hardening [illegible]





Three machines in one Flamatic simultaneous selective hardening three sizes of over-riding clutch cams for automatic transmissions.

Four flame heads [illegible]

Controlling Factor for Dendritic Growth*

CONSIDERABLE progress has been made recently in the studies of solidification of metals and alloys. The present paper is a continuation of these studies and is a fine laboratory investigation of the physical conditions necessary for dendrites to occur and grow in alloy systems.

In discussing this work it is desirable to first review a few of the fundamentals of solidification of alloy systems. When an alloy melt solidifies, redistribution of the solute metal occurs which produces chemical segregation that can be related to the conditions of solidification. For the condition of no convection in the liquid, the solute concentration at the liquid-solid interface will rise as the solid growth proceeds. When a steady-state distribution of the solute in the liquid is reached, the solute distribution is given by

$$C = C_o \frac{(1\text{-}k)}{k} e^{-R/D(x)} + C_o \qquad (1)$$

where C_o = initial solute concentration in the homogeneous melt

R = rate of solidification

D = diffusion coefficient of solute in the liquid

k = distribution coefficient

x = distance measured from the interface into the liquid.

For the rates of growth such as used in the present research, the effect of natural convection for mixing is negligible and the above solute profile exists at the solid-liquid interface. As a result of the above distribution of solute in the liquid, the equilibrium liquidus temperature of the melt varies with distance from the interface. The distribution of liquidus temperature is given by

$$T_E = T_o - C_o \left(1 - \frac{(1\text{-}k)}{k} e^{-R/D(x)}\right. \qquad (2)$$

where T_o = melting point of the pure metal

and m = slope of the liquidus line.

If during the solidification of an alloy the temperature at a given point, as maintained by the temperature gradient in the liquid, is lower than the value of T_E at that point, then that portion of the liquid is said to be constitutionally super-

---

*Digest of "Conditions for Dendritic Growth in Alloys", by W. Morris, W. A. Tiller, J. W. Rutter, W. C. Winegard, ⓐ 1954 Preprint 17.

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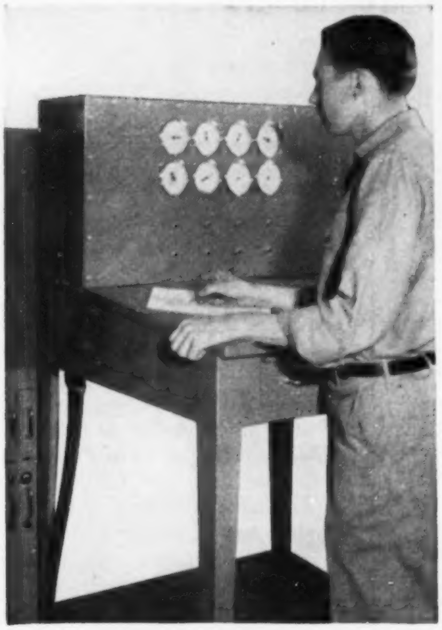

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YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Dendritic Growth . . .

cooled. When this condition exists, a smooth interface is unstable and will change in shape in order to eliminate the supercooling. This change in shape of the interface is revealed by the formation of a substructure of prismatic form termed "corrugations". It was the purpose of this investigation to determine whether dendrites formed under conditions of constitutional supercooling as a natural transition from the unstable corrugation strueture and to determine the conditions of solidification under which transition from one structure to the other took place.

Crystals of lead base alloys containing from 0.25 to 5% tin were grown in a graphite boat using the Chalmers' technique for varying rates of growth and varying temperature gradients. For the alloys studied, the distribution coefficient was approximately 0.5. The top surface of the specimen was examined under a stereoscopic microscope to determine the point at which the corrugations began to show the side branching, which was defined as the beginning of dendritic growth. The transition from corrugations to dendrites was observed on the top surface of the crystals. The interface was investigated during the growth of the crystal by decanting the liquid prior to the formation of dendrites. Only the corrugations in the center of the specimen were considered so as to avoid edge effect due to the graphite boat.

In their discussion, the authors stated the following facts. If the solid-liquid interface remains plane during solidification, the amount of constitutional supercooling, S, is a function of distance from the interface from liquid and is given by

$$S = T_L - T \qquad (3)$$

where T_L is the liquidus temperature given by equation (2) and T is the actual temperature. The gradient of supercooling may be calculated from equation (3) as

$$\frac{ds}{dx} = m\,C_0 \frac{(1\text{-}k)}{k}\frac{R}{D}\,e^{-R/D(x)} - G \qquad (4)$$

However, the zone of constitutional supercooling is unstable and will not persist. If one part of the interface advances slightly ahead of the neighboring areas on account of a local fluctuation of temperature and com-

(Continued on p. 232)

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PROGRESSIVE *Kearney & Trecker Corp.*, Milwaukee, Wisc., reports the following savings by TOCCO hardening the above saddle clamp eccentric of their Milwaukee Milling Machine:

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Dendritic Growth . . .

position, that part will enter a region of greater supercooling. It will, therefore, grow more rapidly than the neighboring interface and a projection will be formed. An array of projections constitutes the cellular interface which accompanies the formation of the corrugation structure. Since the cellular interface is the stable form, the redistribution of solute and temperature which occurs when the structure is present must result in the elimination of the constitutional supercooling. As the conditions of solidification change, the shape of the cellular interface changes to correspond to the extent of the constitutional supercooling which must be eliminated. The present investigation showed that there is a limit to the extent of the constitutional supercooling which can be relieved by an interface of the cellular form. If the amount of constitutional supercooling exceeds that which can be accommodated by a cellular interface, then dendrites develop.

The form of dendrites in alloys depends on the extent of the constitutionally supercooled zone which would exist adjacent to a smooth liquid-solid interface. As previously mentioned, the extent of this zone depends upon the coefficient of diffusion of the solute in the melt, D, the distribution coefficient, k, the slope of the liquidus, m, the rate of solidification, R, and the temperature gradient, G, existing in the melt. For a given alloy, the factors D, k and m are constant. Therefore, the variables which will control the onset of dendrite formation are R and G. Dendrite formation will thus be favored by a rapid rate of solidification and a low temperature gradient.

The results of the laboratory investigation verified that the factor controlling the onset of dendritic growth was the ratio R/G. For each of the lead-tin alloys investigated, it was discovered that the transition from the cellular to the dendritic structure occurred at a definite R/G ratio for each composition. A curve was obtained of R/G versus percentage of tin which showed the critical values of R/G for which the transition in structure occurred.

D. J. Carney

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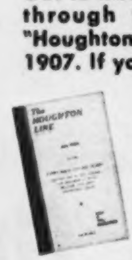

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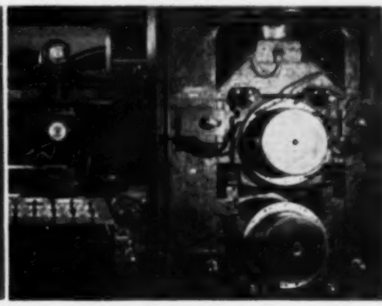

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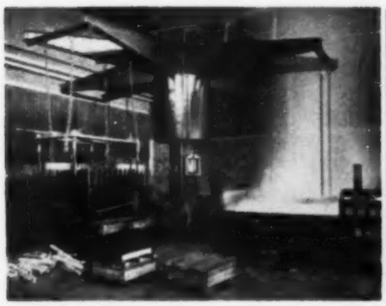

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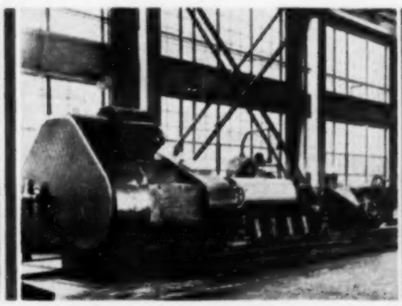

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Effect of Tensile Stress on Isothermal Transformation*

THE EFFECT of externally applied loads on the kinetics of austenite decomposition yields evidence on mechanism of the transformation. The authors set out to establish a quantitative relationship between the magnitude of applied tensile stress and the transformation kinetics in the bainite range. Studies were made on steels A.I.S.I. 1085, 4340, and 1045 at 535 and 700° F., 650 and 845° F., and 700° F., respectively. The transformation of the 0.89% carbon steel at 535° F. (280° C.) is discussed in detail.

The steels were studied in form of wires 0.05 in. diameter and 5.5 in. long. In the heat treatment, the wire was moved automatically from the austenitizing furnace to the isothermal salt bath. To apply the tensile stresses, a system of dead loading was used. The percentage of transformation was determined metallographically, using both a comparison-chart and lineal analysis. The range of applied tensile stresses employed was from 0 to 60,000 psi.

The general effect of applied tensile stresses is to shorten the beginning and ending times of transformation and to increase the rates of transformation. These times are shortened by factors ranging from 2 to 100,000, depending on the steel and temperature of transformation. The effect of applied tensile stresses in the range of 0 to 21,000 psi. is not nearly so pronounced as for the range 33,000 to 60,000 psi. The former are less than the "critical stress" and the latter are greater than this stress. It was found that this critical stress corresponds with the flow stress of the untransformed austenite. Thus, plastic strain is much more effective in inducing the transformation to bainite than is elastic strain.

It is possible to correlate the increase in the amount of austenite transformed with plastic strain and strain energy. It is observed that the

(Continued on p. 240)

*Digest of "Isothermal Transformation of Austenite Under Externally Applied Tensile Stress", by Subrata Bhattacharyya and George L. Kehl, ⊕ 1954 Preprint 22.

Metals

Tensile Stress . . .

rate of decomposition per unit volume of transformed austenite under imposed stress increases with increases in transformation time up to some limiting value and then becomes constant. The onset of a constant decomposition rate is shown to occur at shorter times of transformation the higher the applied stress, and the constant rate increases with increasing stress. It has been observed that the effect of stress on the transformation of austenite persists even when the applied stress is removed. The applied stress is most effective in accelerating transformation when it is applied to austenite after an elapsed time equivalent to the beginning time of transformation under no stress.

The character of bainite formed under applied stress was studied. A preferred orientation in bainite is produced which becomes more pronounced with increasing level of applied stress. Twinning in austenite is observed at applied stresses greater than about 45,000 psi. The mechanical strength of the austenite-bainite aggregate at the transformation temperature is a logarithmic function of the amount of bainite present in the aggregate. Electron misroscope studies revealed no effect of applied stress on the character of the carbides in the bainite.

J. W. Spretnak

Phase Changes During Creep-Rupture Test*

With the growing importance of understanding the creep-rupture properties of alloys, there is increasing need to single out and investigate the many factors affecting these properties. One of these is phase changes. Little is known about the possible effect of stress and strain on the phase changes that may take place during creep-rupture tests. This investigation involved the study of creep stress and strain on a series of low-alloy steels in which the identity

(Continued on p. 244)

*Digest of "Creep-Tempering Relationships in Hardened 4.5% Chromium Steels", by E. C. Roberts, N. J. Grant and Morris Cohen, ⓐ 1954 Preprint 36.

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Creep-Rupture . . .

and kinetics of the tempering reactions under stress-free conditions were well-known.

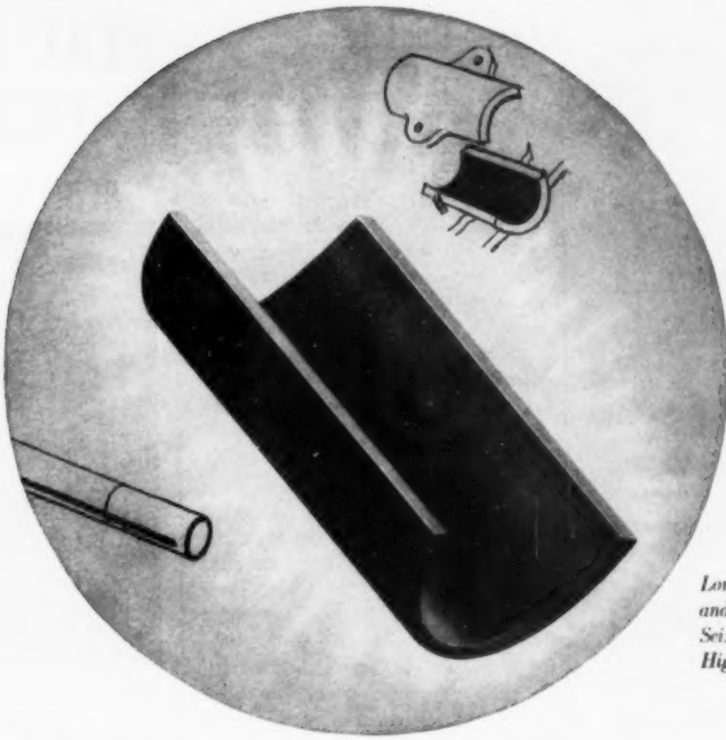
Three carbon contents (0.16, 0.40 and 0.68%) of a steel with 4.5% chromium were selected. In these steels $(Cr,Fe)_7C_3$ is the stable carbide phase, but, preliminary to the nucleation and growth of this phase, cementite $(Fe,Cr)_3C$ is precipitated. The formation of cementite constitutes the third stage of tempering, while the development of $(Cr,Fe)_7C_3$ and the concurrent disappearance of the cementite comprise the fourth stage of tempering in these chromium steels. The overall objective was to determine the effect of stress and strain on the rate of formation of $(Cr,Fe)_7C_3$, and simultaneously, to ascertain the influence of this tempering reaction on the concommitant creep-rupture properties. The test temperatures were chosen primarily in the fourth stage of tempering (800 to 1300° F.).

Hardness and electrical resistance measurements were employed to delineate the second, third and fourth stages of tempering in the hardened steels and to evaluate the effect of stress on the fourth stage. The second stage of tempering was indicated by an increase in resistance, unlike conditions in plain carbon and most other alloy steels. The third and fourth stages were accompanied by successive decreases in resistance. Electrolytic extraction studies showed that the $(Fe,Cr)_3C$ formed during the third stage of tempering was replaced by $(Cr,Fe)_7C_3$ during the fourth stage.

By interrelating the information obtained on the time dependency of the tempering reactions and the creep characteristics of these steels, it was shown that the application of stress during the fourth stage of tempering (the formation of $(Cr,Fe)_7C_3$) produced no consistent change in the tempering reaction rate from that found in unstressed specimens.

This insensitivity was attributed to the fact that the underlying reaction is diffusion-controlled, and the rate of diffusion is not affected much by stress unless the corresponding strain rate is considerably higher than is encountered in the usual creep studies.

(Continued on p. 246)



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Creep-Rupture . . .

This insensitivity was also found to be true for the associated hardness changes, except for specimens tempered at 1300° F., for which the hardness was found to decrease more rapidly under stress than without stress. The latter phenomenon was considered to result from an increased rate of agglomeration of the carbides on tempering under stress.

Other significant findings were that hardened 4.5% chromium steels are not suited to creep testing at 800 and 1000° F. because they undergo intergranular fracture before appreciable creep takes place; and that, on testing and tempering at 1200 and 1300° F., the high carbon (0.68%), 4.5% chromium steel has higher strength than the lower carbon steels (0.16 and 0.40%) only for short testing times. As the time of testing was increased, the strength of the high-carbon steel decreased more rapidly than that of the lower carbon steels. This was attributed to the intergranular type of failure found in the high-carbon steel, initiated under stress by preferential carbide precipitation of the grain boundaries during the fourth stage of tempering. W. L. Finlay

Grinding Damage to Hardened Steel*

The effects of heat generated in the grinding process are of extreme interest to those who make machined parts of hardened steel. If such heat is excessive, the structure and the state of residual stress in the material beneath the ground surface can be altered to the detriment of the product.

Previous investigators have shown that a thin layer of steel just beneath the ground surface may be austenitized, quenched, and partially tempered as a result of grinding. The depth of these changes is a function of grinding severity.

Because the damage produced by grinding in hardened steel should be related to its thermal history, the

(Continued on p. 248)

*Digest of "The Influence of the Grinding Process on Structure of Hardened Steel", by Walter Littman and John Wulff, 1954 Preprint 11.

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The illustration shows Rockwell furnaces for carburizing, crucible melting, bright annealing, casting annealing, aluminum annealing and coil wire annealing—all equipped with Spencer Turbo-Compressors.

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Grinding Damage . . .

authors undertook the measurement of temperature distribution during the grinding of hardened steel specimens and the correlation of these data with resulting structural changes.

Small samples of A.I.S.I. 52100 steel were austenitized at 1550° F. for 1 hr., oil quenched, and tempered at 300° F. for 1 hr. to a hardness of Rockwell C-64.

The temperature distribution in space and time was measured for points at various depths by means of thermocouples placed at known distances below the surface to be ground. Temperatures were recorded, by means of an oscilloscope, as a function of time for each grinding pass. Thus the thermocouple moved a known incremental distance closer to the surface with each pass until it was ground through.

The principal variables used to control severity of grinding were the abrasive, the downfeed, and the work speed. Force measurements were made with strain gage dynamometers to permit correlation of grinding energies with temperature distribution.

Structural changes caused by heat of grinding were evaluated by microscopic examination and microhardness surveys of taper sections of the ground specimens. From these studies it was found that even under very severe grinding conditions the depth of the rehardened layer was only 0.0001 in.

Because of the relatively poor accuracy of temperature measurements at extremely shallow depths, it was necessary to use an indirect method to confirm the temperature required to form austenite during grinding. For this purpose rapid heating was accomplished by electrically heating thin (0.007 in.) strips of the steel and quenching in vacuum. The temperature of the heated strips was obtained by means of an infrared-sensitive lead sulphide cell in conjunction with an oscilloscope.

Experimental results revealed that for heating rates of 11,000° F. per sec., austenite formed between 1510 and 1540° F. Heating rates beneath ground surfaces ranged from 30,000 to 500,000° F. per sec., depending on work speed and feed, and the

(Continued on p. 250)

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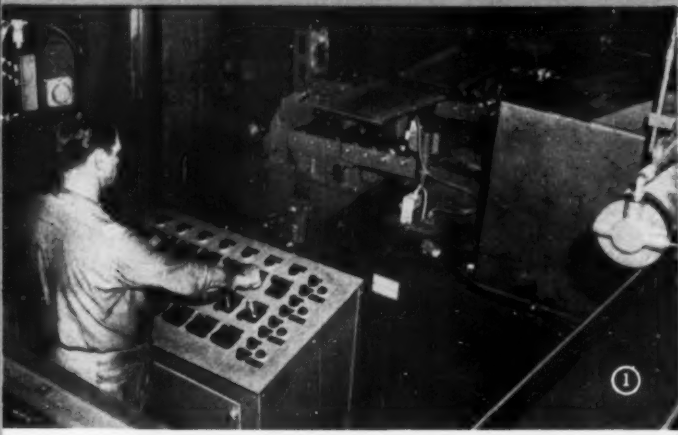

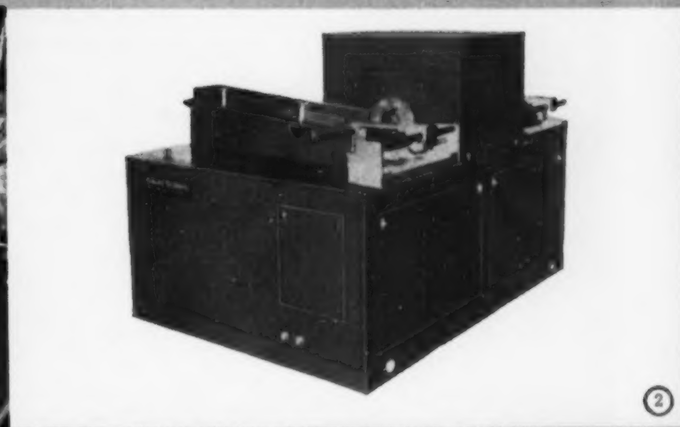

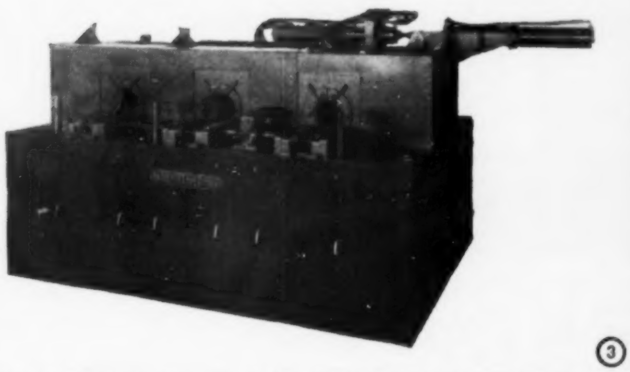

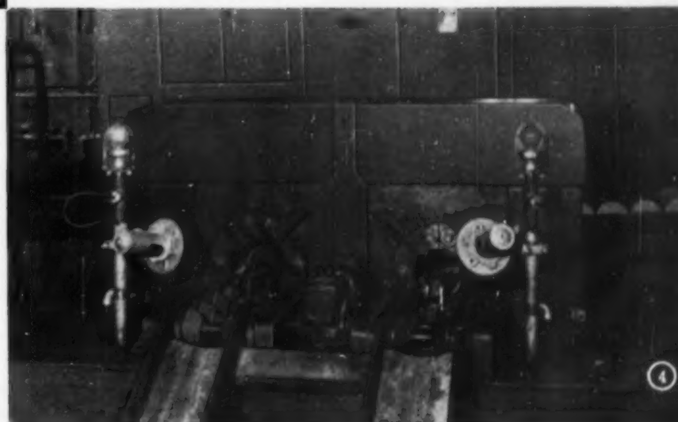

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Grinding Damage . . .

magnitude of the peak temperature.

The relationships between temperature and grinding conditions were carefully studied, and the existence of a correlation between temperature distribution and energy expended in grinding was confirmed. This led to a quantitative expression of grinding energy as a function of the horizontal force component, the grinding surface speed and work speed. From this relationship it was possible to estimate the depth at which a given peak temperature would occur from known grinding conditions. W. W. AUSTIN

Laves and Chi Phases*

THE POSSIBILITY of producing an age hardenable ferritic stainless steel appears real as a result of recent studies which have furnished data on potential precipitate systems. For this investigation a 12% chromium, 4% molybdenum alloy was used, to which were added varying amounts of titanium.

The alloys were induction melted and cast into 25-lb. ingots which, after homogenizing, were forged to ⅝-in. squares, annealed and oil quenched from 1700° F. X-ray, metallographic and quantitative chemical determinations were used to establish the nature of the precipitate phases obtained as a function of titanium content.

Nominal analysis of the melts showed the following: 0.04 to 0.08% carbon, 0.43 to 1.65% manganese, 0.34 to 0.81% silicon, 0.018 to 0.034% phosphorus, 11.35 to 12.00% chromium, 0.08 to 0.12% nickel, 3.92 to 4.12% molybdenum, 0.07 to 0.71% aluminum.

Titanium contents for the samples were within the following range:

SAMPLE NO.	TITANIUM
185	0.11%
186	0.74
187	2.53
188	3.14
189	2.87

Metallographic examinations prior to etching showed the presence of

(Continued on p. 252)

*Digest of "The Laves and Chi Phases in a Modified 12 Cr Stainless Steel", by F. L. VerSnyder and H. J. Beattie, Jr., Ⓐ 1954 Preprint 28.

Chi Phase . . .

titanium carbo-nitrides in all heats. These mechanical inclusions were ignored in the study.

In this examination it was found that the samples could be arranged chronologically in order of increasing amount of precipitate. Only a minor amount of precipitate (as a fine spheroidal phase throughout the structure) occurred in sample 185, while samples 186 and 187 showed correspondingly large increases. However, sample 189 showed the presence of a third phase, and the amount of this phase increased in sample 188 at the expense of the initial precipitate phase.

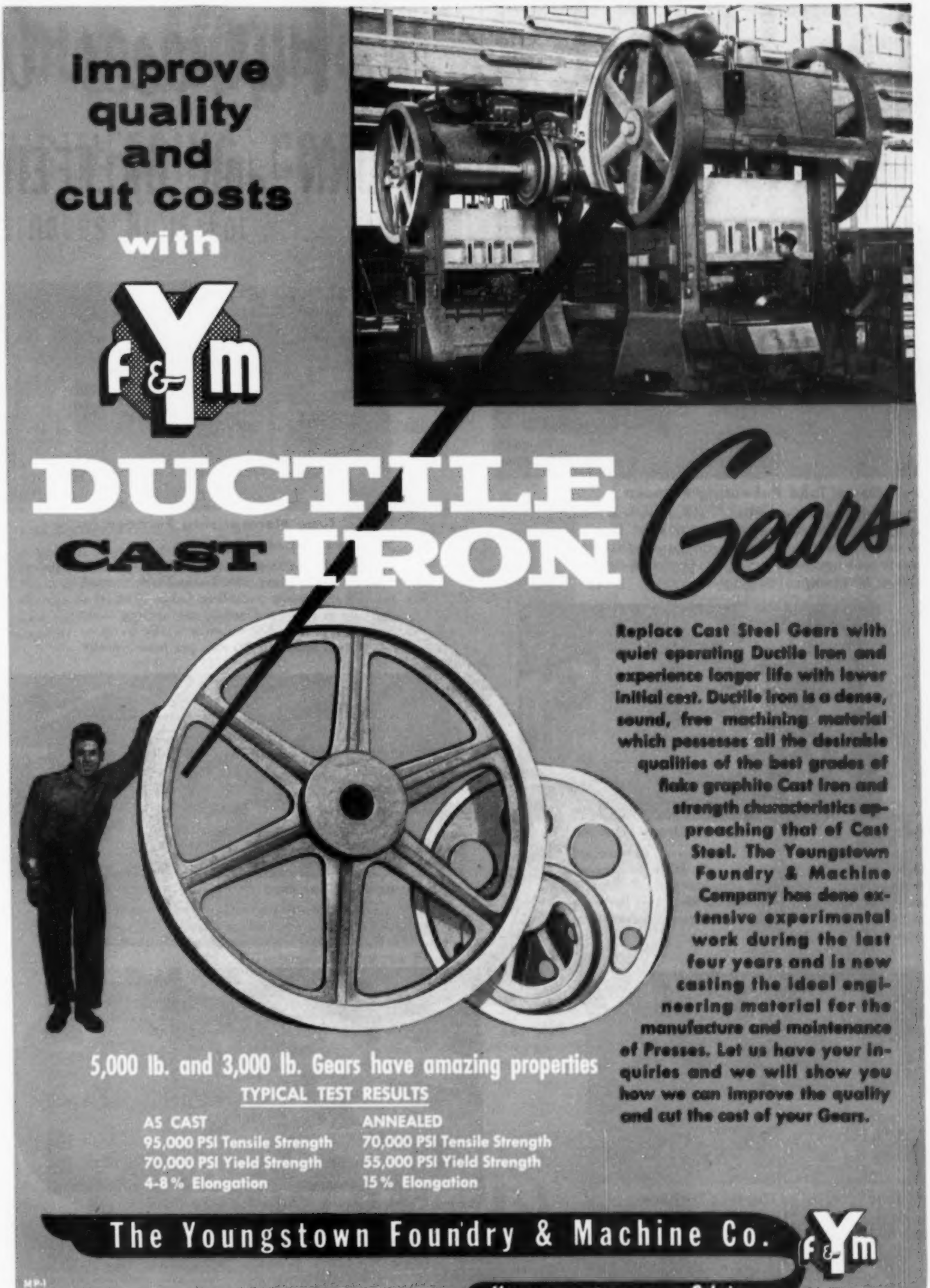
Sample 187, containing the maximum amount of primary precipitate, was electrolytically digested and the precipitate was extracted. X-ray studies indicated a structure in the hexagonal system, C6/mmc, with parameters $a_0 = 4.768\text{A}, C_0 = 7.79\text{A}$, and $C_0/a_0 = 1.63$. No extraneous lines were found.

Since the compound seemed completely segregate, quantitative analyses were run on the residue. Results showed a definite concentration of titanium, molybdenum and silicon in the precipitate, with aluminum remaining in the matrix. Ultimate correlations of X-ray and chemical studies showed that the compound belonged to the AB_2 class. Line intensity calculations allowed the postulation of a suitable hexagonal structure whose composition is represented by the formula $(Ti_{21}Mo_9)(Fe_{50}Cr_5Si_5)$.

Residues of sample 188 after electrolytic dissolution gave two distinct X-ray patterns, one of the laves type described above, the other the chi phase. Of the two, the chi phase was more abundant. No attempt was made to determine the composition of the chi phase, but parameters (cubic, $a_0 = 8.885\text{A}$) indicate that it has a composition of the class $M_{23}C_6$, in which the molecules that constitute M do not exceed 5% molybdenum.

This investigation indicates that by the addition of titanium, a precipitation hardening system may possibly be achieved in a ferritic stainless steel. Increased titanium contents appear to promote formation of the chi phase.

J. L. Wyatt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Nitrogen-Arc Welding of Copper Promises Economies*

ARC WELDING of copper has always been a problem because of its high thermal conductivity, expansion, and its facility for absorbing gases when in the liquid state. Gas welding is widely used, particularly for thick sections, but because a postwelding treatment is necessary to produce adequate joint strength, the method is slow and costly. In general, the use of either carbon or metal-arc welding involves the use of highly alloyed filler rods and preheating, both of which contribute to uncertain quality characteristics of the resulting weld.

Argon-arc welding has been commonly used for joining copper and copper alloys when high-quality joints are required. However, the welding of copper above ¼ in. thick requires considerable preheating and very high welding currents. Also, the cost of argon makes the method expensive and, in welding copper, the high cost of argon cannot be offset by the same kind of reduction in labor cost for postweld cleaning as is possible with aluminum and its alloys.

Nitrogen is a possible alternative to argon since its cost is only a fraction of that of argon and it is insoluble in copper below 2552° F. For the same current setting, the arc in a nitrogen atmosphere yields a considerably lower current than it does in argon. Generally, over-all arc voltages in the nitrogen-shielded arc are about one-third higher than the corresponding argon-shielded arc.

Increased arc voltage is advantageous because more arc heat can be generated for the same arc current than with the lower voltage arc in argon. The larger voltage gradient may be advantageous in machine welding where arc length is controlled by instruments actuated by changes in arc voltage.

In the work described by Davis and Terry, pure tungsten and thori-

(*Continued on p. 258*)

*Digest of two articles entitled "Nitrogen-Arc Welding of Copper", by E. Davis and C. A. Terry, and by K. Winterton, *British Welding Journal*, Vol. 1, February 1954, p. 53-64 and p. 87-90, respectively.


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Welding Copper . . .

ated tungsten electrodes were used. The thoriated tungsten electrode showed an over-all arc voltage of about 2 v. less than that with the pure tungsten electrode in an argon atmosphere. In a nitrogen atmosphere the excessive "arc wander" at low currents and pronounced tungsten transfer at high currents with the pure tungsten electrode prevented any accurate comparison. Although arc wander at low currents with the pure tungsten electrode occurs in both atmospheres, it disappears when the whole diameter of electrode tip is molten.

Experiments with coating the pure tungsten electrode to prevent globule formation were only partially successful because the coating volatilized after a short time. The thoriated tungsten, containing 1% thoria, maintained a stable arc in nitrogen and without tungsten "spatter" for test periods up to 10 min. with currents up to 400 amp. in a ⅛-in. diameter electrode. The absence of molten tungsten at the electrode tip made it possible to use a pointed electrode, thus insuring arc stability over wide current ranges.

It became apparent that the heating effect of the arc in nitrogen was greater than that of the arc in argon, even when the power input and arc length were the same. To measure the relative heating efficiencies, test beads were made under standard conditions, without adding filler metal, on plate ⅜ in. thick. The gas flow was 19 cu.ft. per hr. and speed of arc travel nearly 6 in. (15 cm.) per min. with an arc length slightly more than 3/16 in. (0.5 cm.). The relationships between the extent of the fused zone and current and power input are shown by Fig. 1.

In the preliminary tests of joint preparation both single-V and double-V grooves were tried with included angles of 45°, 60° and 90° and root faces of 1/16, ⅛, 3/16 and ¼ in. With the double-V groove it was difficult to obtain good root fusion, and the necessary chipping and welding could be more easily performed with the single-V groove. Hence, the single-V groove was used to obtain the test data reported.

No difficulty was experienced in welding ¼-in. deoxidized copper in one pass with a single-V groove of 60° included angle and 1/16-in. root face. On ⅜ and ½-in. plate, a 60° single-V with ⅛-in. root face was used and, after welding the groove,

(Continued on p. 260)

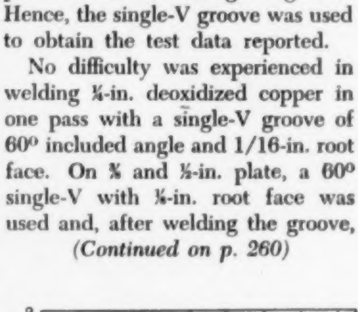
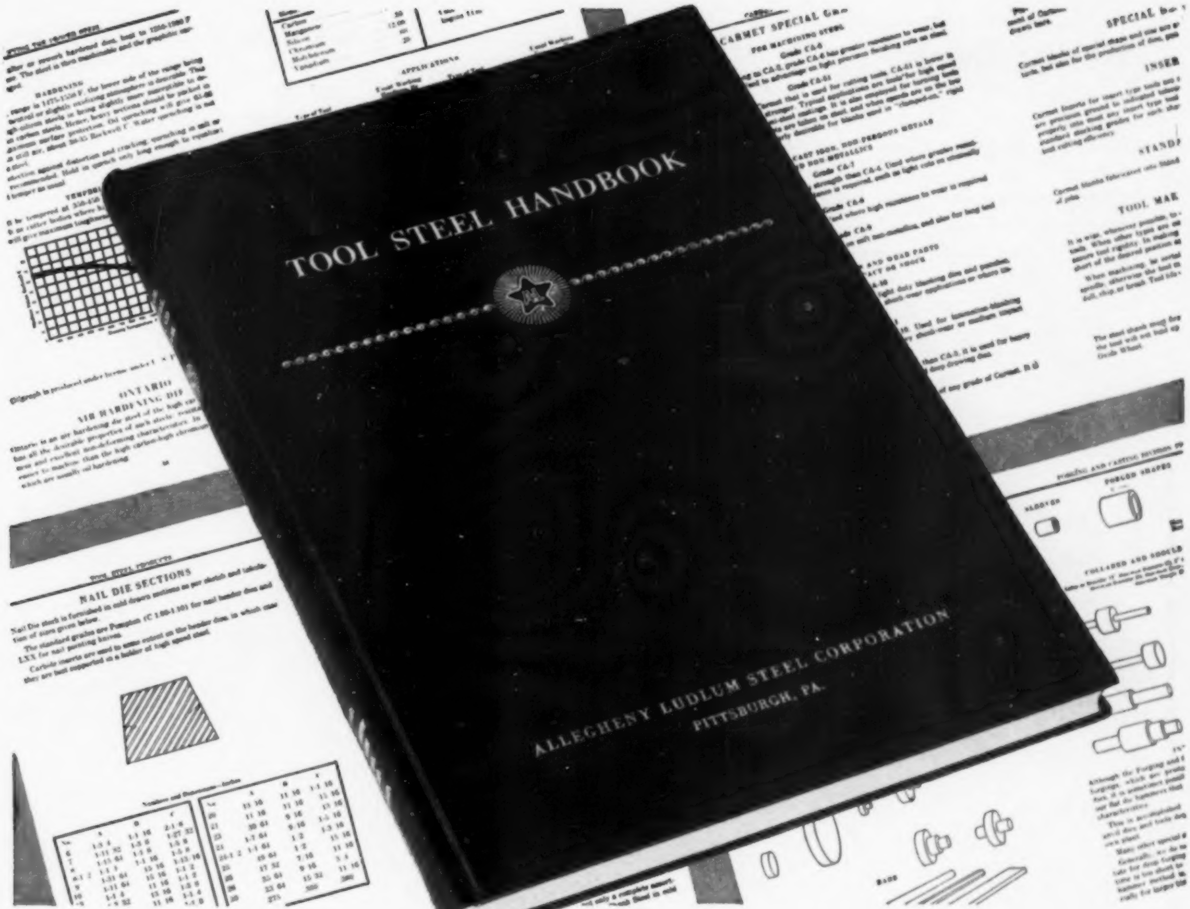


Fig. 1 – Relationship of Penetration and Bead Width to Arc Current and Power Input, in Argon and Nitrogen-Shielded Arcs



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Welding Copper . . .

the back was chipped out and a back bead applied. Test welds were 12 in. long and the root opening at the starting end was 1/16 and ⅛ in., respectively, with an allowance of ⅛ in. per ft. of joint length for contraction during welding. The welds in the ⅜ and ½-in. plate were made in two passes with a back bead.

Normal multipass welding techniques, in which a small initial bead is laid down, could not be utilized because longitudinal cracking occurred in the initial weld bead. This was overcome by laying down a large first bead using a rightwards progression. Thoriated tungsten electrodes up to 5/32 in. diameter were used with direct current electrode negative, and a gas flow of 29 cu.ft. per hr. for leftwards welding and 39 cu.ft. per hr. for rightwards welding. The higher rate of gas flow with the latter technique is necessary to give adequate protection to weld metal.

Welds were made in a nitrogen atmosphere with a 3% silicon bronze filler in deoxidized copper from 1/16 to ⅜ in. thick and with a 1% silicon bronze filler in ⅜ and ½-in. plate. The filler metal was sluggish and the clean weld pool commonly seen with argon-arc welding was absent.

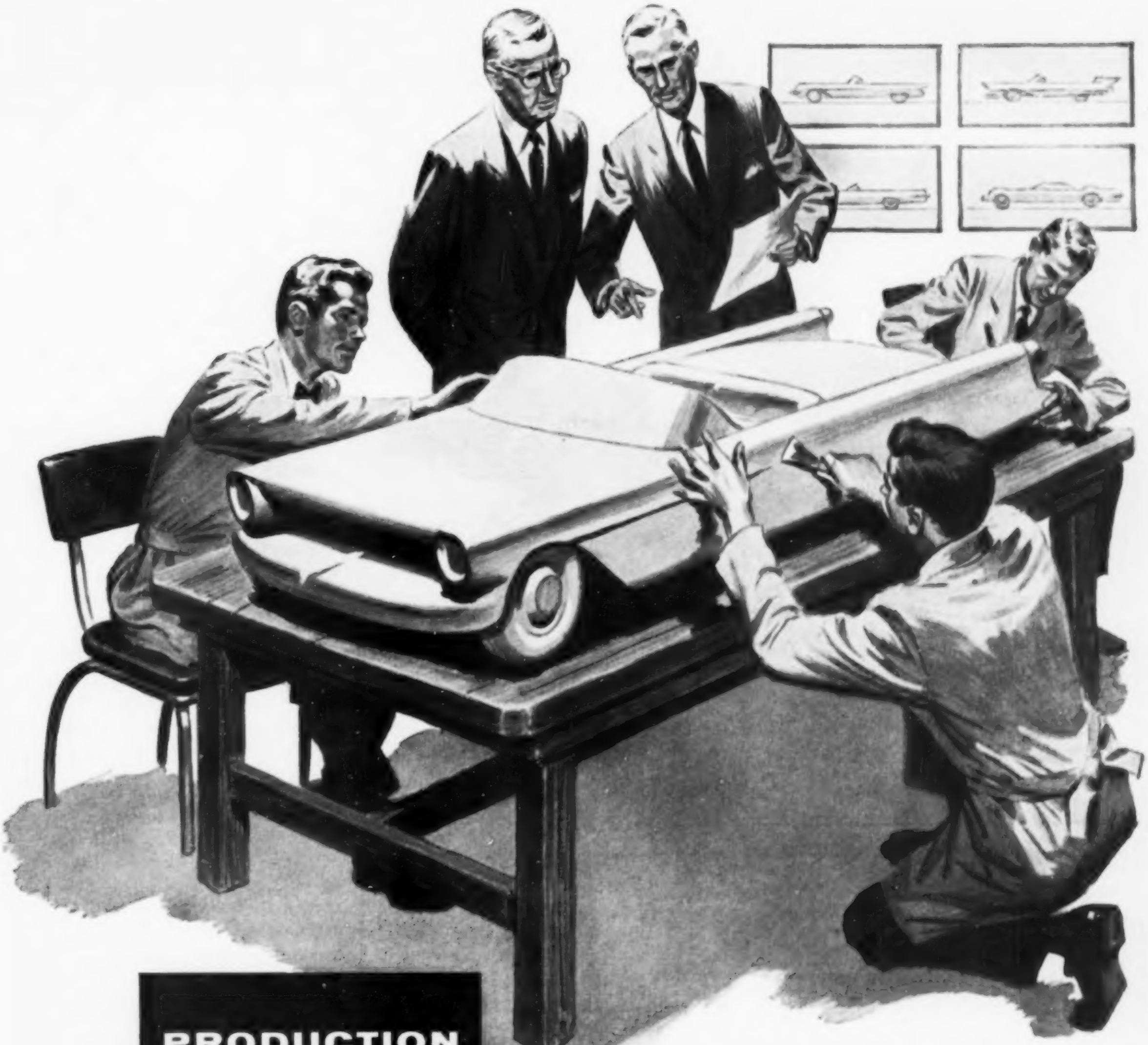
In the welding of plate thicker than ¼ in. it was found easier to use the rightwards technique for the first pass and the leftwards technique for subsequent passes and the back bead. Care was exercised to start each pass from the same end of the joint.

The welds made with the 3% silicon bronze filler were less porous than those made with the 1% silicon bronze filler. With the former, strength of the weld approached that of the plate (27,000 to 30,000 psi.) and fracture occurred at the bond. The weld strength for the 1% silicon bronze filler was lower (20,400 to 23,600 psi.) with the fracture again occurring at the bond. Average plate strength was 30,000 psi.

Since it is known that improvement in weld metal soundness in deoxidized copper results from the use of filler metal which contains substantial amounts of deoxidizers, it was decided to try filler metals containing small separate amounts of magnesium, aluminum and titanium and one containing aluminum and titanium together.

With the copper-aluminum filler (0.04 and 0.26% Al), the higher aluminum content eliminated gross porosity and produced a joint strength nearly that of the plate (27,000 to 28,800 psi.). With the copper-titanium filler (0.1 and 0.2% Ti), the weld appearance was comparable with welds made in argon. In order to obtain adequate penetration a higher welding current was needed than was required with the silicon bronze filler. The filler of higher titanium content gave joint strength equivalent to that of the plate (30,000 psi.) with good ductility and no gross porosity.

With the copper-magnesium filler (0.02% Mg) the welding characteristics were similar to those of the copper-aluminum alloys. This filler metal gave a joint strength equivalent to that of the plate and the arc visibility was good.



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Welding Copper . . .

With the copper-titanium-aluminum filler (0.2% Ti, 0.1% Al) the welds in plate up to ¼ in. thick gave strength and ductility equal to that of the plate. Welds in ⅜ and ½-in. plate were made in two passes with a leftwards technique followed by chipping the back and depositing a back bead. (The rightwards technique was found impracticable because the reduced shielding caused formation of a pronounced oxide skin over the weld metal. Weld soundness was excellent although an oxide film on the weld pool made the filler metal sluggish. The welds produced a joint strength approximately equal to that of the plate (27,600 to 29,600 psi.) with full plate ductility (39 to 69% in 2 in.).

The results of this work indicate that welds in deoxidized copper are sound provided that the filler metal is adequately alloyed. A 0.1% titanium-copper alloy appears particularly suitable for plate up to 3/16 in. thick, and for heavier plate a copper alloy of 0.2% titanium and 0.1% aluminum appears to be effective in producing sound welds of adequate strength. The use of a thoriated tungsten electrode in the nitrogen-shielded arc eliminates arc instability and tungsten loss. Nitrogen-shielded arc welding can be performed with standard welding apparatus.

Table I – Test Welds on Deoxidized Copper (Winterton)

Shield	Electrode	Filler	Tensile	Elong.
Argon	Tungsten	3% Si	30,000	51%
Argon	Tungsten	Copper	24,800	21
Argon	Carbon	3% Si	29,000	53
Nitrogen	Carbon	3% Si	30,000	44
Nitrogen	Carbon	Copper	20,000	14
None	Carbon	3% Si	29,800	38

In the work described by Winterton, both tungsten and carbon electrodes were used in the welding of deoxidized copper ½ in. thick. A 60° single-V groove with 1/16-in. root face and root opening of 1/16 in. was used with two filler metals – one, a 3% silicon bronze and the other, copper with a small deoxidizer content (not identified). A tungsten electrode ⅜ in. diameter and a carbon electrode ½ in. diameter were used. The rate of gas flow was 34 cu.ft. per hr. for argon and 40 cu.ft. per hr. for nitrogen, and no back beads were applied to the welds. Welding current ranged from 390 to 425 amp. with electrode negative. Both electrodes were used with the argon shield but only the carbon electrode was used with the nitrogen shield. One test with the carbon-arc and the 3% silicon bronze filler was made without any shielding. Test welds were 8 in. long.

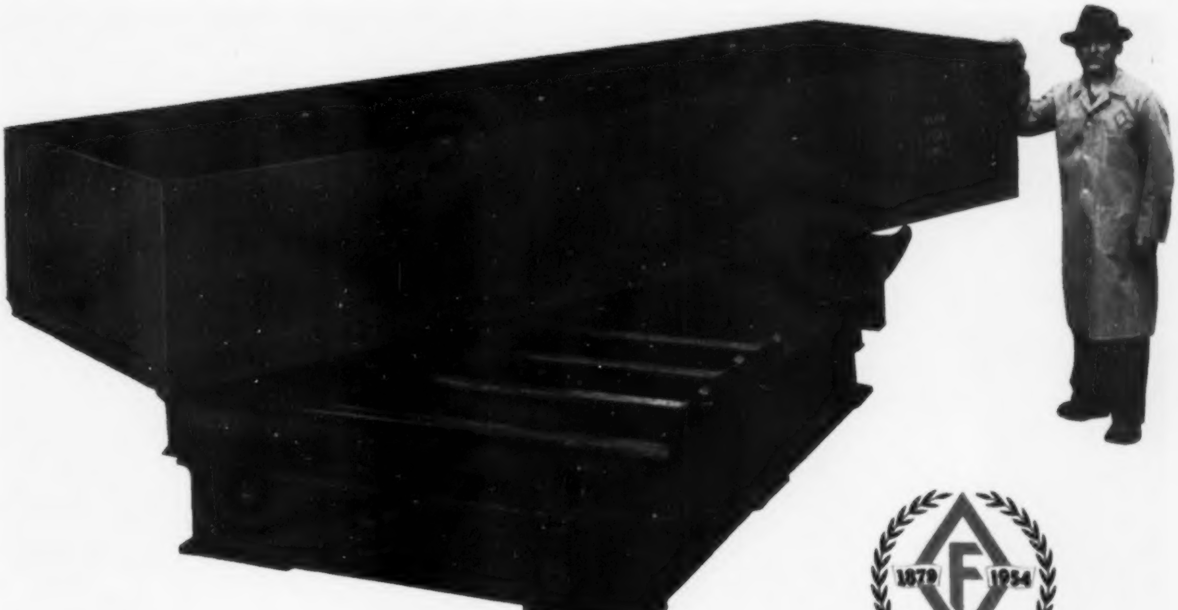
The tensile properties of the welds are indicated by the average values shown in Table I.

It is noted that the ductility of the nitrogen-shielded welds is not as good as that of the argon-shielded welds. It is possible that increasing the nitrogen flow to improve the shielding might raise these ductility values.

Macro and micro-examination of these welds indicates a difference in heating effect between the arc in argon and the arc in nitrogen of similar order to that pointed out by Davis and Terry. When no shielding was used in the test with the carbon arc the weld exhibited considerable porosity.

Taking into account the ratio of welding time to total welder time and the cost of joint preparation as well as the effect on gas consumption of the nature of the welding job, it is suggested that the substitution of nitrogen for argon may result in an over-all saving in welding costs of 30 to 60%.

William L. Warner



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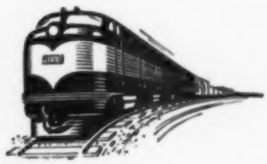
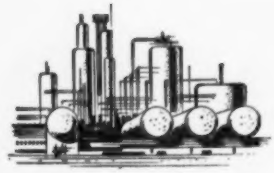


Take large sections—where hardness must be carried deep into the steel. Heavy crankshafts, connecting rods, piston rods, large gear and axles are examples. Here alloy steels *are necessary*, and the cost low in proportion to results. With carbon held constant, depth-hardening quality increases as the alloy content is increased.

Sometimes weight and space limitations demand that smaller sections carry heavier loads safely. For safety's sake, the answer *must be* alloy steels. Under repeated stress, high tensile strength and hardness do not necessarily indicate high fatigue properties. The load-carrying ability of a steel depends upon its alloy constituents and the form of the structure at the time it is bearing the load.



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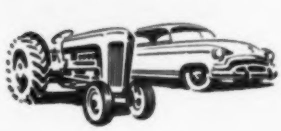

High elastic properties and strength may be the primary requirement, especially for welded structures. Weight reduction may be most important. In these applications, low carbon complex alloy steels *offer distinct advantages*. Such alloy steels at equal or higher yield points show low weld-hardening tendencies. Resistance to corrosion is improved. So is ductility of the weld. And retention of toughness at sub-zero temperatures, as well as creep resistance at high temperatures, is better.

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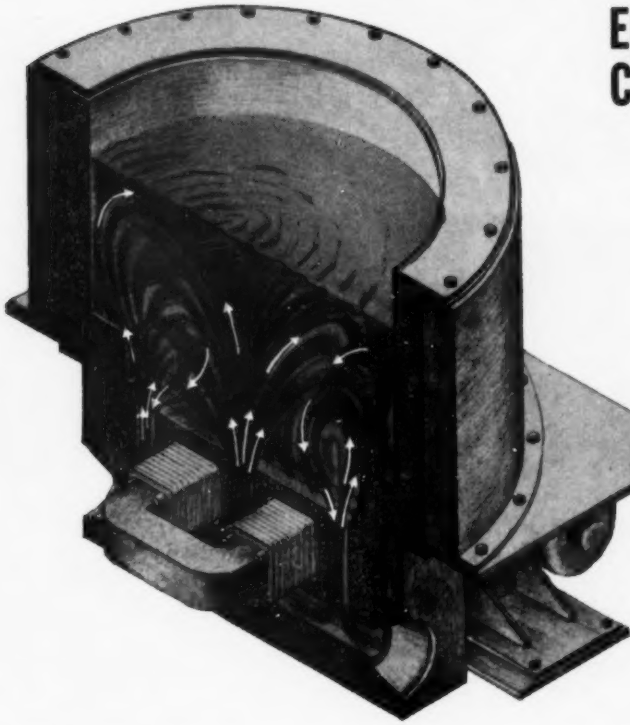

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No Other Method Enables Such Completely

CONTROLLED MELTING

Today, AJAX builds a complete line of these time-tested furnaces in standard sizes up to 333 kW for the dependable melting of aluminum, brass, copper and zinc. Units for special applications are carefully engineered to specifications.

TWIN COIL INDUCTORS

Lead Non-Ferrous Melting

The sectional view above shows the twin coil stirring action of the 100 kW Ajax-Tama Wyatt 60 cycle induction furnace. Heat induced in the secondary channels below is conveyed throughout the melt by electromagnetic circulation as shown by the arrows. The 100 kW furnace shown here, which will be on display at the 1954 Metal Show, is one of a family of twin coil furnaces available today for melting rates from 300 to 10,000 lbs. per hour.

We cordially invite you to inspect the 100 kW AJAX furnace exhibited at the NATIONAL METAL SHOW, Chicago, Nov. 1-5, 1954, Booth #752.

AJAX ENGINEERING CORP., TRENTON 7, N.J.

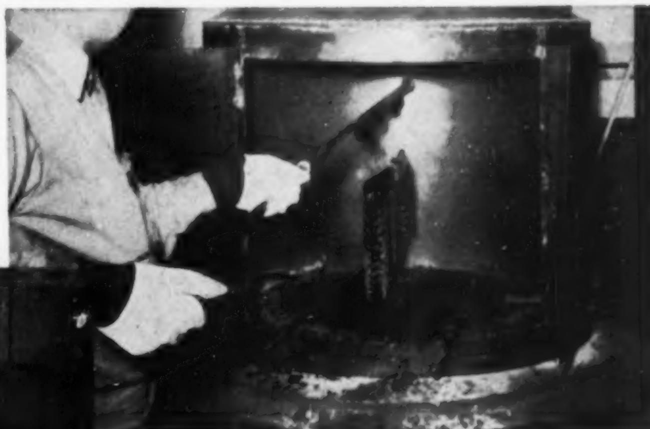
AJAX TAMA-WYATT **INDUCTION MELTING FURNACE**

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

"Our Formula for Successful Quenching"

SAYS RAGAN RING CO., ATLANTA, GEORGIA

Out of the Furnace...



...into SINCLAIR QUENCHOL 521

Ragan Textile Rings must be uniformly hard, completely free of flaws and must have the smoothest finish obtainable.

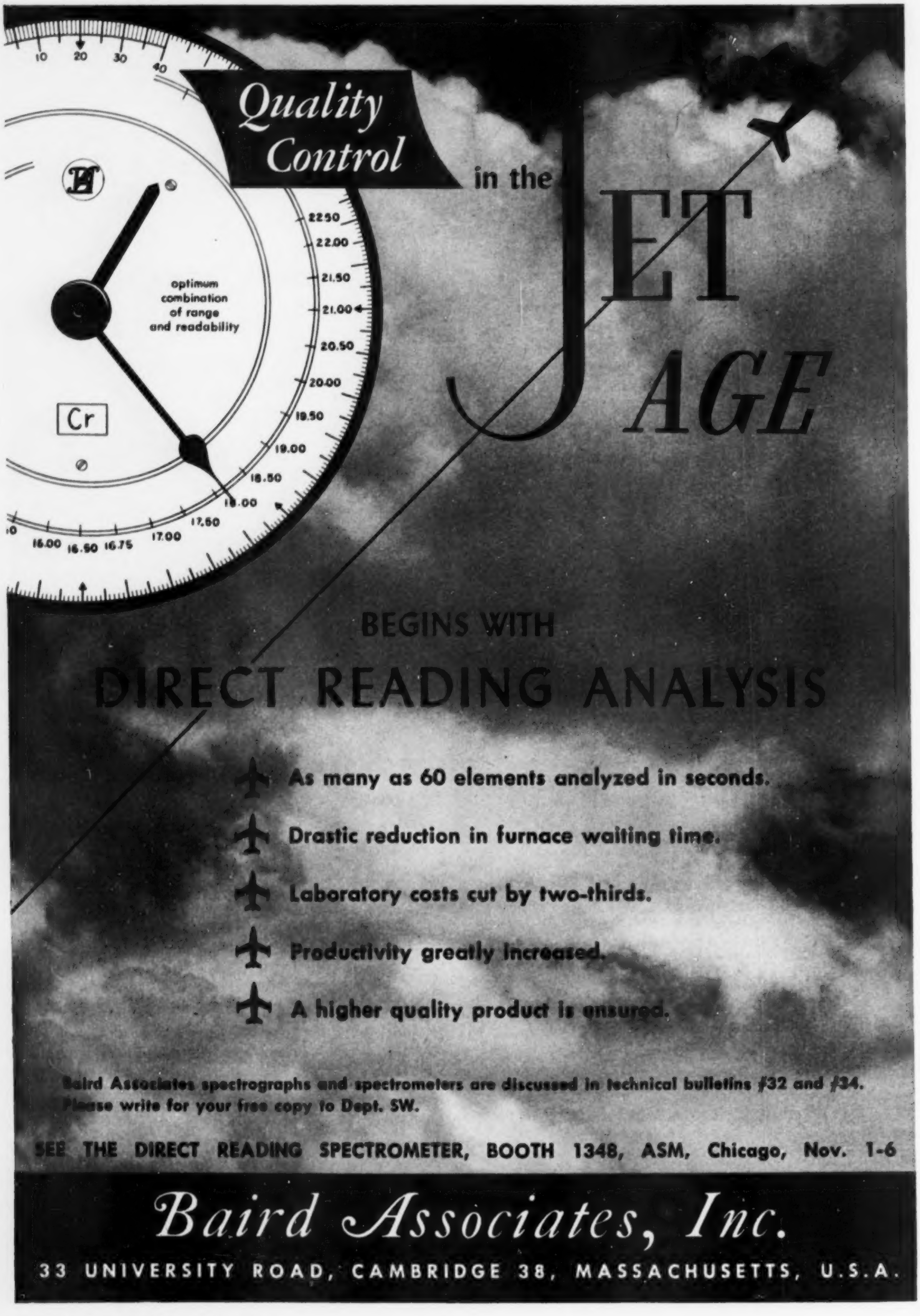
To get these results from cold drawn seamless tubing, Ragan Ring Co. uses Sinclair QUENCHOL 521.

Ragan Ring says, "When, for economical reasons, we installed our own heat treating furnaces and were looking for one of the best quenching oils on the market to heat treat our top quality rings, we naturally looked to the man in whom we had absolute confidence – our Sinclair Engineer. He recommended QUENCHOL 521 and gave us a demonstration of what it would do. We put our new system into operation with QUENCHOL 521 in the tank.

"We are getting even better results than before – more uniform hardness, and no signs of flaws."

For a demonstration of this revolutionary new quenching oil, call your local Sinclair Representative, or write for a new booklet about QUENCHOL 521 to the Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y.

SINCLAIR CUTTING OILS and COOLANTS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Baird Associates spectrographs and spectrometers are discussed in technical bulletins #32 and #34.
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SEE THE DIRECT READING SPECTROMETER, BOOTH 1348, ASM, Chicago, Nov. 1-6
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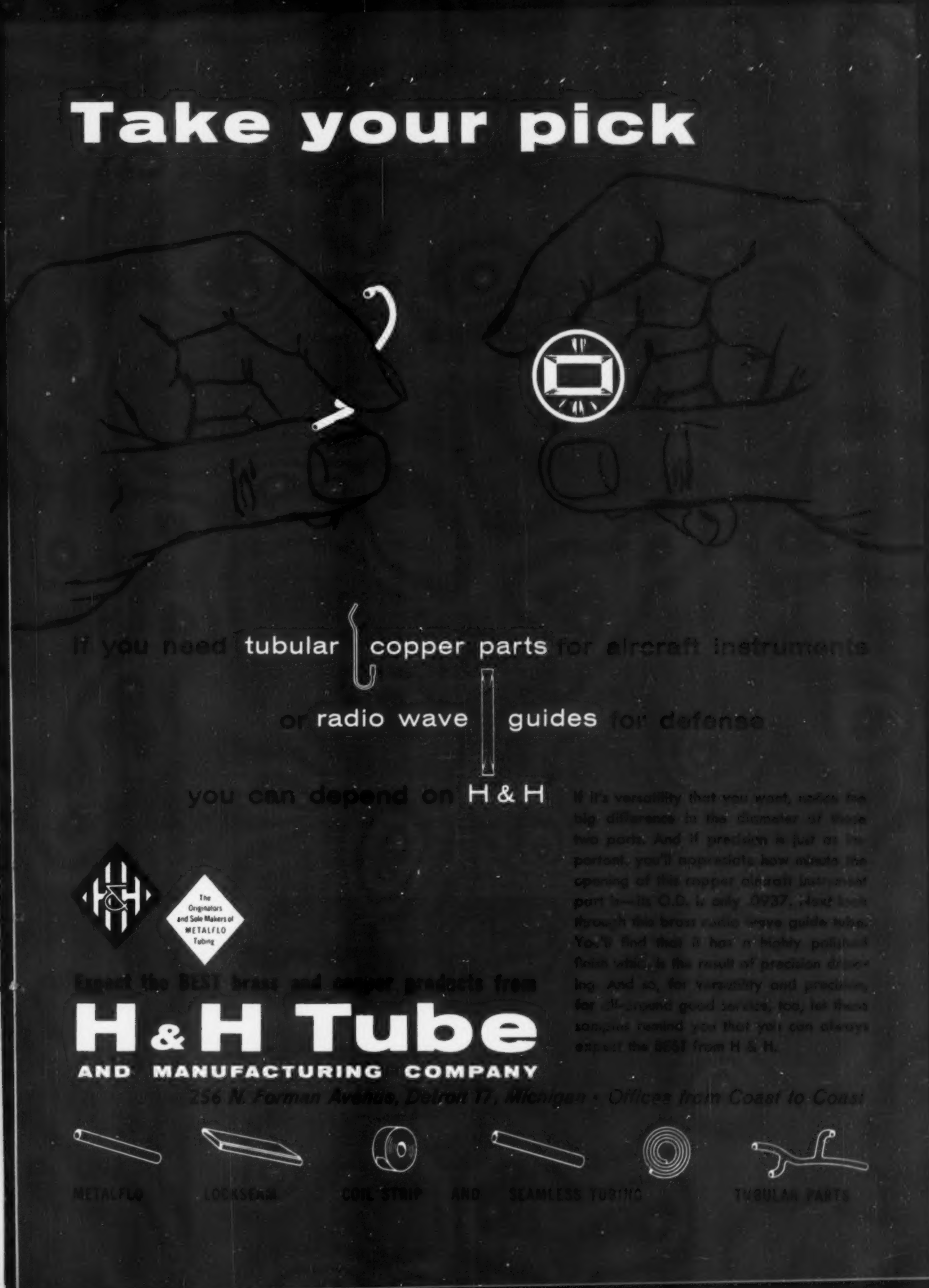
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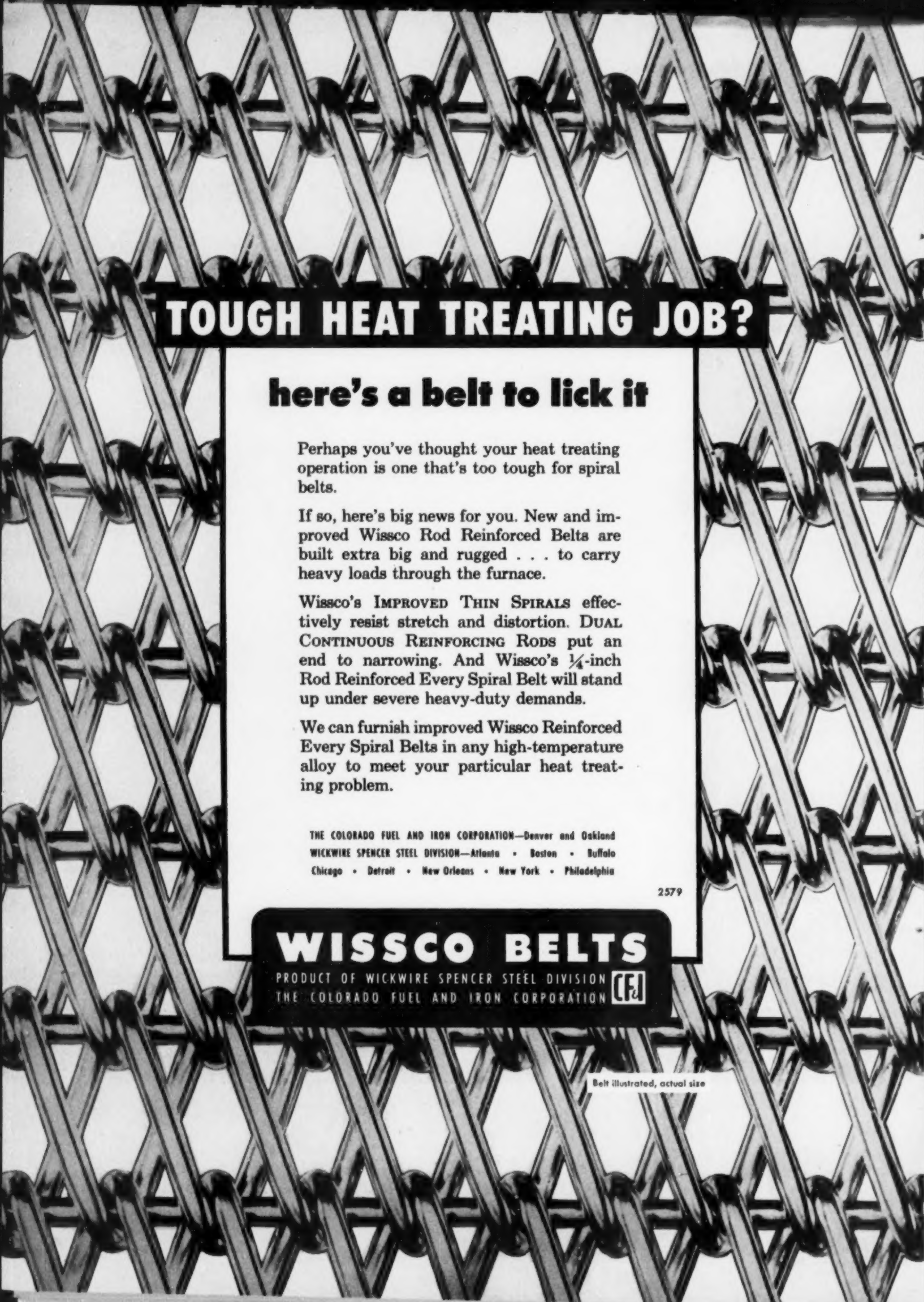

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here's a belt to lick it

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Wissco's IMPROVED THIN SPIRALS effectively resist stretch and distortion. DUAL CONTINUOUS REINFORCING RODS put an end to narrowing. And Wissco's ¼-inch Rod Reinforced Every Spiral Belt will stand up under severe heavy-duty demands.

We can furnish improved Wissco Reinforced Every Spiral Belts in any high-temperature alloy to meet your particular heat treating problem.

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WISSCO BELTS

PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION
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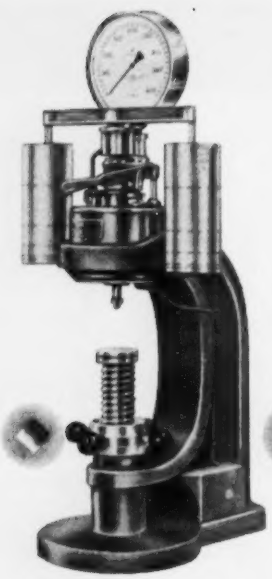
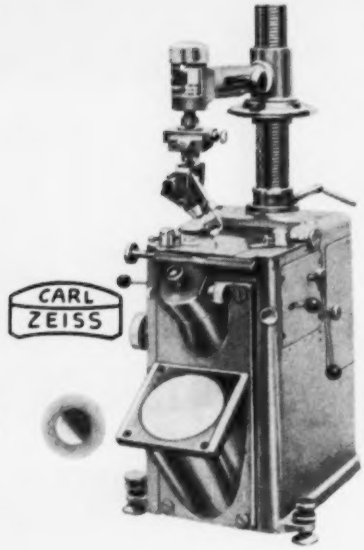
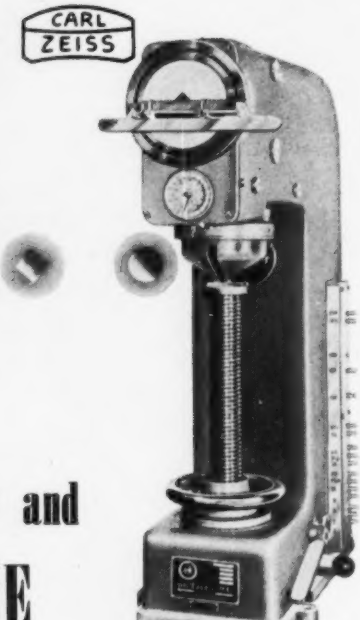
Belt illustrated, actual size







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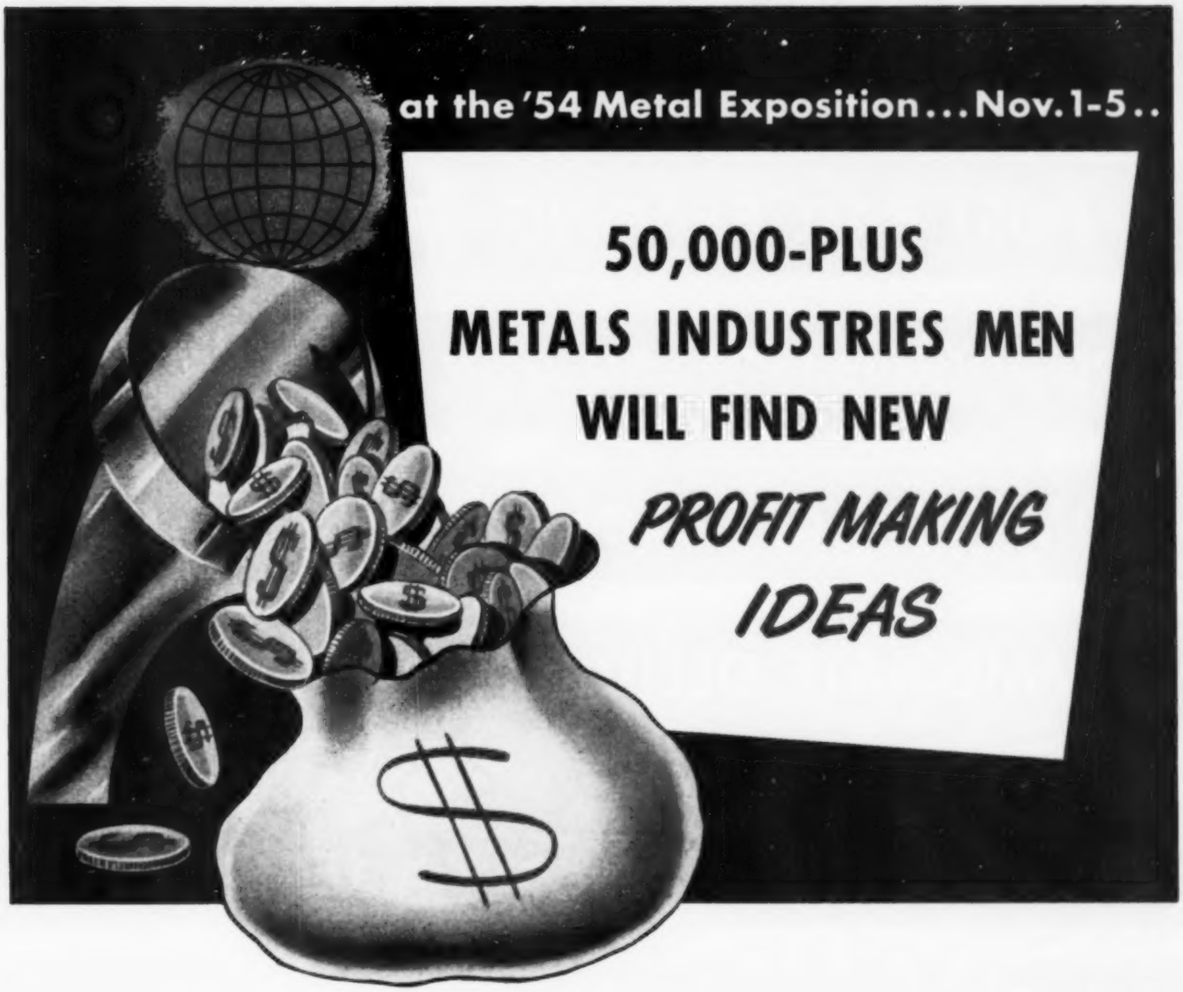

Searching for new product ideas . . . shooting for sharp competitive advantages, this great audience of metals industries men will be checking carefully into everything that's new . . . improved . . . outstanding in the metalworking field. What's more—they'll find what they're looking for—and they'll go away with more profit-making ideas than ever before! That's why today's tough competition demands your presence at the '54 Metal Show—its the one place where industrial profit-making ideas are born!

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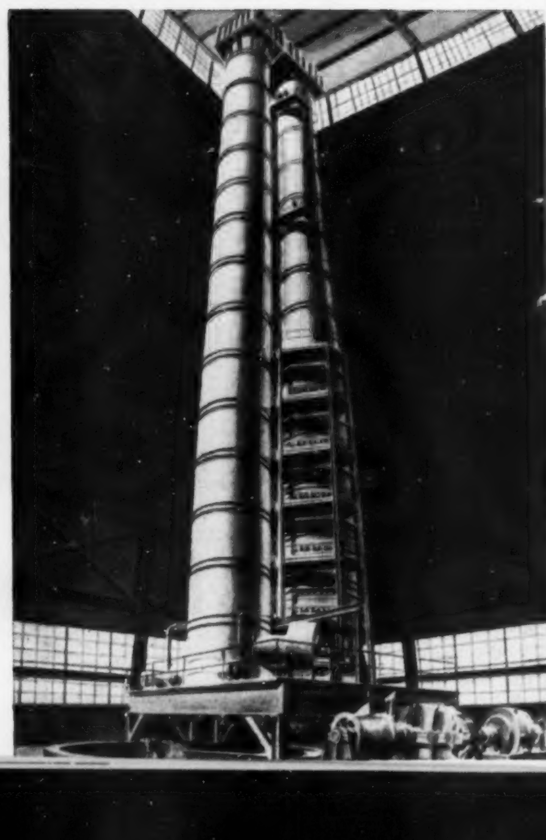

FROM BOX TYPE TO ELEVATOR TYPE . . . this wide range of Westinghouse furnaces offers industry heat-treating units specially engineered for the smallest toolroom jobs on up to furnace capacities for massive parts treating. Accurate temperature control, uniform temperature distribution and low heat loss in Westinghouse furnaces assure high and constant quality level.

Needles to cannon barrels...

heat-treat them in Westinghouse furnaces

Across the board in heat-treating, for small jobs or mass production, Westinghouse makes the exact furnace needed. From manually operated box type to complex automatic conveyor units, Westinghouse furnaces assure the maximum in speed, quality and economy.

This complete line includes furnaces using either gas or electric heat source . . . atmosphere generators providing all gas variations required . . . and auxiliary equipment to speed and simplify work handling.

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POWER-O-MATIC

A NEW PRINCIPLE IN LABORATORY OVENS

HARSHAW SCIENTIFIC announces the Blue M "POWER-O-MATIC" ovens with "Con-Wate" mechanical convection

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- ★ **Temperature range to 316°C. (600°F.)**
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- ★ **Automatic heat recovery**

Power-O-Matic—a new heating system which achieves "straight line" temperatures through automatic wattage control. Heart of system is hydraulic type thermostat equipped with 5 contacts operating in sequence. Each contact works into a 6-volt relay which in turn applies power to 5 heater elements. When control unit is set at selected temperature, all heater elements are energized; as selected temperature is approached, heater elements are turned off one by one. To maintain selected temperature, minimum number of elements, usually one, will be switched on and off to compensate for heat losses and work-load heat absorption.

Con-Wate—a new mechanical convection system which provides constant weight of air at all temperatures. Normally, heat transfer decreases as air temperature in an oven increases. Con-Wate compensates for this by automatically providing increased supply of air. This results in constant heat transfer and more efficiency.

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SPECIFICATIONS AND PRICES

H-52920—Ovens—Blue M, Power-O-Matic, with Con-Wate mechanical convection, bench models. Models POM-38 and POM-48 have 2 doors. For 230 volts, 60 cycle, single phase, A-C.

MODEL NUMBER	INSIDE DIMENSIONS (W. x D. x H. IN.)	OUTSIDE DIMENSIONS (W. x D. x H. IN.)	MAX. WAT.	PRICE
POM-14	14 x 14 x 14	44 x 20 x 32	2800	546.00
POM-20	20 x 18 x 20	50 x 24 x 38	4000	649.00
POM-25	25 x 20 x 20	59 x 26 x 38	4400	759.00
POM-38	38 x 20 x 25	68 x 26 x 43	5800	975.00
POM-48	48 x 24 x 36	78 x 30 x 54	8500	1595.00

H-52925—Ovens—Blue M, Power-O-Matic, with Con-Wate mechanical convection, floor models. Models POM-130 and POM-140 have 2 doors. For 250 volts, 60 cycle, single phase, A-C.

MODEL NUMBER	INSIDE DIMENSIONS (W. x D. x H. IN.)	OUTSIDE DIMENSIONS (W. x D. x H. IN.)	MAX. WAT.	PRICE
POM-100	14 x 14 x 14	30 x 25 x 62	2800	546.00
POM-110	20 x 18 x 20	37 x 29 x 65	4000	649.00
POM-120	25 x 20 x 20	45 x 31 x 65	4400	759.00
POM-130	38 x 20 x 25	59 x 31 x 68	5800	975.00
POM-140	48 x 24 x 36	72 x 35 x 73	8500	1595.00

(NOTE: Models POM-14 and POM-100 are also available for 115 volts, 60 cycle, A.C.)

Any model can be furnished with stainless steel exterior at 20% over the above prices.

★ ***Contact the nearest Harshaw Scientific office for complete details on Power-O-Matic***

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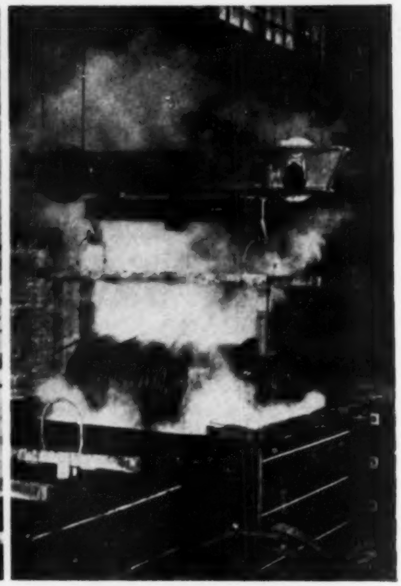

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In 10 to 20 minutes, sheets, bars, wire, rods, forgings and fabricated articles are completely descaled with the Du Pont Sodium Hydride Descaling Process. Even heavily scaled forgings (½" scale thickness) take less than an hour. And in only 15 seconds you can get cold reduced-annealed strip clean and bright!

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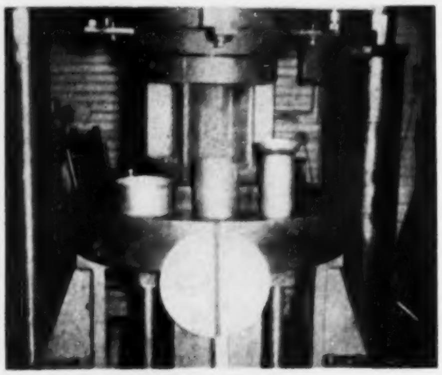

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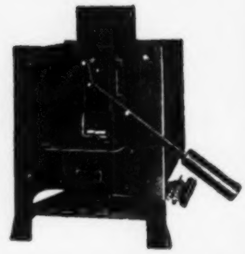

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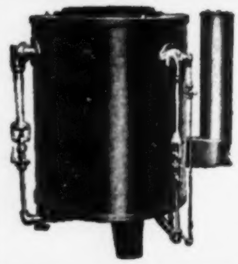

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FOR

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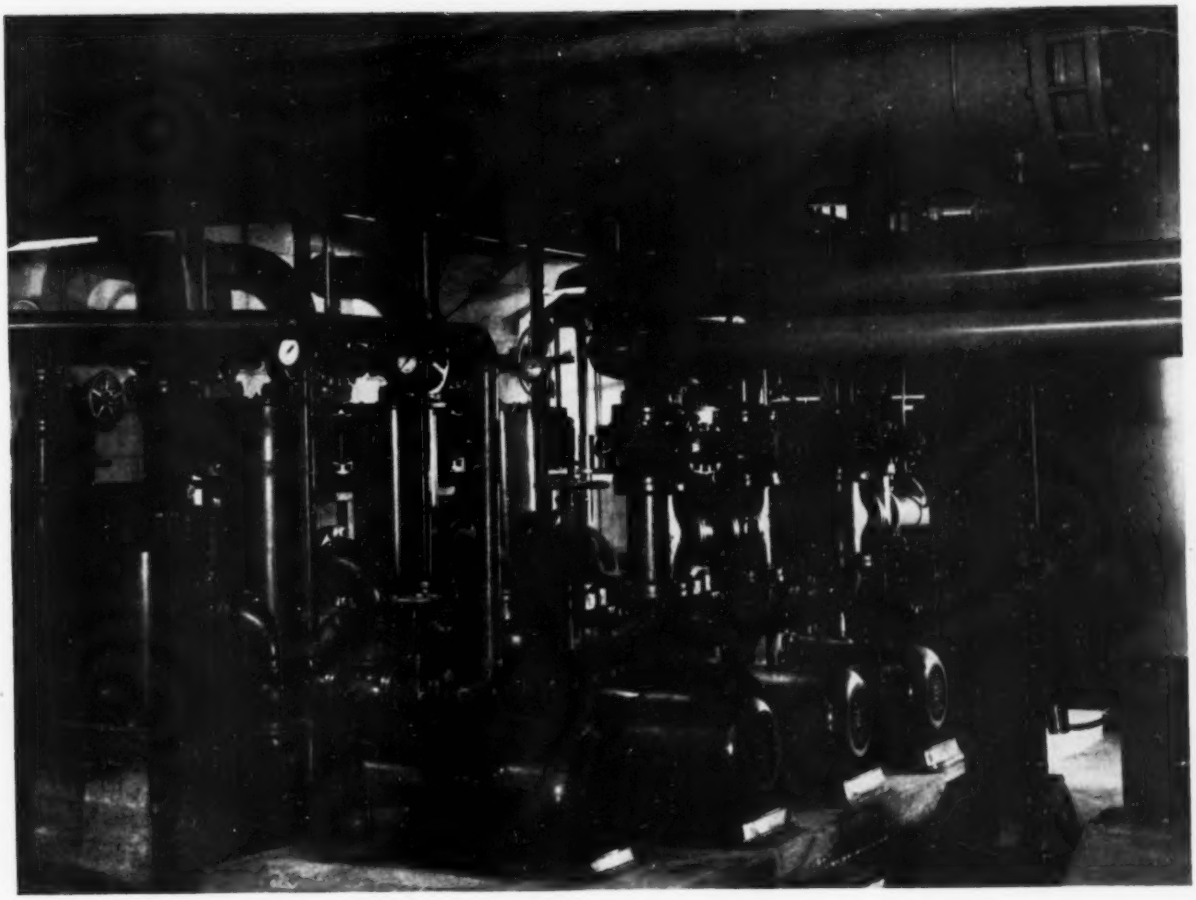

Battery of B & G Quench Tanks served by B & G Oil Cooling System illustrated above.

Metal Progress

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